

Consequences of moderate caloric deficit in a full time college student: a case report

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ABSTRACT

A 21-year-old male student was referred to the Bates Bobcat Nutrition & Exercise Clinic with concerns of inadequate caloric intake, reduced physical activity and complaints of fatigue and difficulty concentrating. Following a 4-week intensive study, we assessed his metabolic health based on a number of factors including calorie consumption and energy expenditure, diet, sleep and exercise patterns. Although the quality of our patient's diet appeared to be satisfactory - the distribution of carbohydrates, fats, and proteins and levels of vitamins and minerals fell within normal limits - we did find a significant discrepancy in the number of calories consumed per day compared to his daily energy expenditure. In particular, our patient spent all but three days in a caloric deficit, averaging a net caloric intake of -858.73 kcal/day. Consequently, our patient showed mild weight loss, and changes in body composition. Therefore, we advised him on ways he could improve his health and navigate a busy college schedule.

CASE HISTORY INFORMATION

A 21-year-old male student was referred to the Bates Bobcat Nutrition & Exercise Clinic for a 4-week, intensive study and analysis of his metabolic health. Upon arrival, the patient recorded a weight of 70.3 kg and height of 172 cm, producing a calculated body mass index (BMI) of approximately 23.8 kg/m² and a basal metabolic rate (BMR) of 1754 kcal/day. The subject claimed to once being in excellent physical condition, but due to the coursework required to complete a triple-major, he reported inconsistent levels of activity during any given week. Our subject noted that the frequency of his exercise routine was often inversely proportional to the amount of work he had at the time, and because he found his workload to be high most of the

time, he suspected that he was not getting enough weekly exercise. Due to the fact that the subject walks daily to and from class and maintains at least one high-intensity workout per week, his estimated daily energy expenditure (DEE) was 2,412 kcal. Additionally, the subject complained of increased fatigue (bordering on lethargy) and difficulty concentrating. Therefore, he was instructed to keep a diet and exercise journal and return in 4 weeks for a follow-up evaluation.

METHODOLOGY

The data was collected and stored via two electronic assistive devices. To record meal data, the subject employed Samsung's proprietary S Health mobile application. The "Food" section of the application contained a comprehensive library of food items through which the subject could search. Associated with each food item was its estimated nutritional properties among which was caloric content. In this way, for each meal/snack, the participant could record the date and time of consumption, a brief description of the food item (including serving size), the number of calories and the distribution of carbs, fats, proteins and sugars. These data were manually transferred to an excel spreadsheet for further analysis.

The activity and exercise data were collected through the use of a Fitbit Charge HR™ Wireless Heart Rate + Activity Wristband. This device allowed for continuous and automatic monitoring of heart rate throughout the day as well as an estimate of the amount of time spent in a certain heart rate zone. Additionally, this tracker recorded various parameters associated with daily activity and workouts, such as distance traveled, calories burned, floors climbed, active minutes and number of steps. Lastly, based on accelerometer data, the Fitbit tracker gave an estimate of the subject's sleep quality based on the the amount of time asleep or awake, and number of times restless.

PRESENTATION OF THE DATA

According to the data obtained from the subject's self-reported dietary journal kept over the four-week period, our patient consumed approximately 1913 kilocalories per day on average. The distribution of proteins, carbs and fats that comprised the patient's average caloric intake is shown in figure 1. The majority of the patient's food intake came from carbohydrates, consisting of 51% of the net food mass (g) consumed, with 21% coming directly from dietary sugars, to make up 41% of the total caloric intake. Interestingly, although fats made up only 19% of the net consumed food mass, they contributed 35% (almost double the mass percentage) to the total caloric intake. This is due to fat's high kcal/gram ratio. Fluid consumption was fairly consistent but inadequate, with approximately 1 liter of water and 16 oz of coffee consumed per day. In the follow-up interview, our patient reported inconsistent consumption and logging of a multivitamin and 5000 IU vitamin D supplement, stating that he likely consumed these supplements anywhere from 2 to 5 times a week.

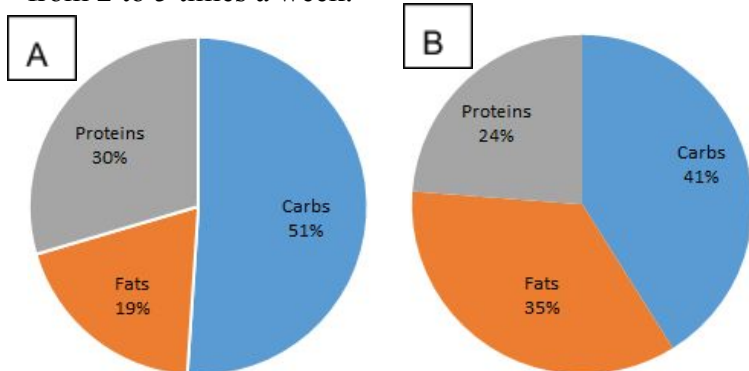
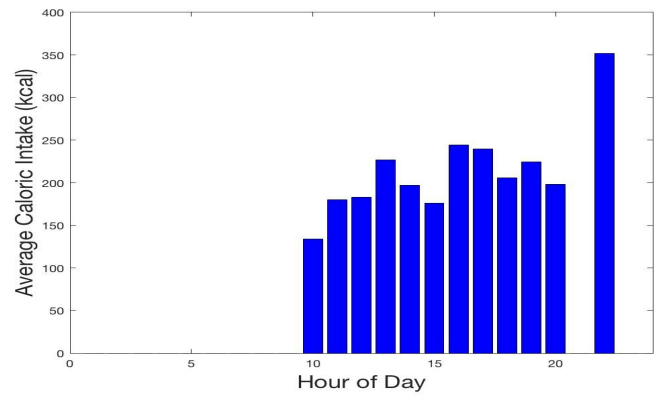


Figure 1: Distribution of carbohydrates including sugars, fats, and proteins when considered in the context of (A) total food mass consumed (g) and (B) total caloric intake.

Over the four-week period, our patient did not consume food outside the hours of 9 am to 11 pm, and average caloric consumption tended to increase as the day progressed, attaining a maximum average of approximately 250 kcal from 4:00 - 5:00 pm and 350 kcal from 10:00 - 11:00 pm due to instances of heavy snacking on Kind Fruit and Nut Bars (figure 2).

Figure 2: Our patient’s average caloric intake as a function of the hour of the day revealed a mild increase in calorie consumption as the day progressed, obtaining a maximum at approximately 10:30 pm.



The Fitbit activity monitor revealed that, on an average day, our patient took 13,101 steps, walked 5.91 miles, climbed 15.83 floors and expended 2881.5 kcal. Occasional weekend workouts were recorded and coincided with increases in caloric expenditure and consumption. Comparing our patient’s net caloric intake to his energy expenditure, we see that he spent almost the entire 4-week period in a caloric deficit, maintaining an average net caloric intake of -858.73 kcal/day and attaining a caloric surplus on only 3 of the 25 days that energy expenditure data was available (figure 3). Despite being in a caloric deficit for most of the study, our patient spent very little time in a postabsorptive (fasting) state, with an average interval of 2 hours and 17 minutes spent between food consumption periods during the day and an overall average fasting time of 5 hours and 7 minutes (including overnight fasting).

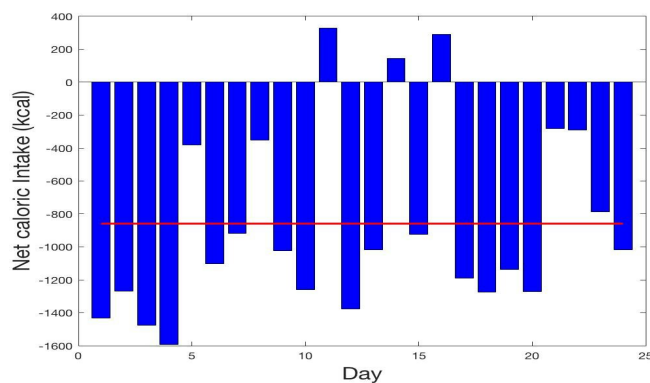


Figure 3. Our patient’s net caloric intake over a 24 day period revealed an average of -858.73 kcal/day (red line) and a caloric surplus attained on only 3 days.

As for sleep over the 4 week period, our patient averaged 7 hours and 16 minutes per night, sleeping as little as 2.5 hours on 2/01/16 and as much as 9.5 hours on 2/14/16. Assuming

that the recommended amount of sleep per night is 8 hours, this equates to 22 hours of sleep debt, or almost 3 nights worth. Sleep quality, as assessed by the number of times awake/restless, fluctuated over the 4-week study and was often positively correlated with periods following increased physical activity and inversely correlated with exams/high stress periods (figure 4). Interestingly, our patient's average resting heart rate saw an overall decrease over the 4 week period, dropping from 69 to 67 BPM. However, large fluctuations in resting heart rate were observed, attaining a maximum of 72 BPM during the exam week of 02/07/16. In the follow up examination, our patient recorded a weight of 67.9 kg, producing a calculated BMI of 22.9 kg/m², which is a 4% reduction over the 4-week study.

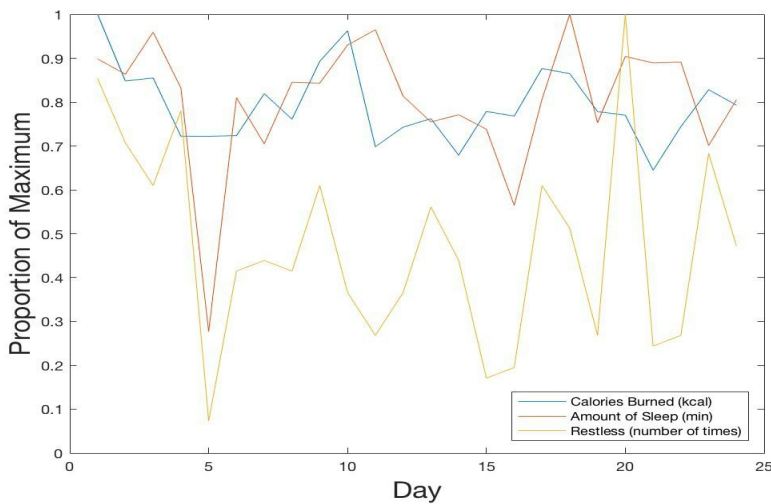


Figure 4. Line plots of calories burned, amount of sleep and number of restless times over the course of 24 days. Each quantity has been normalized to the maximum value obtained during the study.

ANALYSIS AND BIOCHEMICAL PERSPECTIVE

Upon initial examination of the data, it became quite apparent that our patient was simply not consuming enough calories during the study, averaging less than 2000 kcal per day. This is a mere 200 kcal greater than his BMR, and considering that his measured average DEE was actually 470 kcals greater than our original estimates, our patient maintained a caloric deficit for all but three days of the study. In order to maintain body weight, an individual must stay in caloric balance, *i.e.*, his net caloric intake must equal his DEE. Since our patient consumed less

energy than he burned, his body had to draw on his adipose tissue to meet his energy demands. In particular, since he expended approximately 859 more kilocalories than he consumed each day, our patient accumulated a net deficit of 20,616 kilocalories over the 24 day period for which we had energy expenditure data. Since an individual will lose approximately 1 lb whenever he expends 3500 kcal more than he consumes, our patient should have lost approximately 5.89 pounds over the 24 days, which is fairly consistent with his measured weight loss of 5.3 lb (Note: the study actually ran longer than 24 days, so we would have expected a weight loss of 6+ pounds). To explain the mild discrepancy between the observed and predicted weight loss, we appeal to the fact that on follow-up exam, we noted significant changes in body composition with slight accumulation of adipose tissue around the mid-section and significant loss of muscle mass. It is probable that our subject slightly underestimated his daily caloric intake, and that the majority of the weight loss was due to mild underuse muscle atrophy, since muscle has a comparatively high mass density.

Beyond inadequate calorie consumption, the nutritional quality of our patient's diet appeared to be satisfactory in most areas, but left room for improvement in others. First, the distribution of proteins, carbs and fats fell within normal limits. Of particular note was his protein consumption (112 g/day), which was approximately twice the RDA of 0.8 g of high quality protein per kilogram of ideal body weight. Although there is no significant evidence that would suggest this slightly elevated level of protein consumption is harmful, we suspect that our patient may have been in a slightly positive nitrogen balance and exhibited increased urea cycle activity. Additionally, we observed that his fat intake was just below the value of 35% of total dietary calories.

With respect to vitamins and minerals, we have no reason to suspect that our patient is deficient or consuming excess amounts. Although sodium was not explicitly tracked, based on

the patterns in our patient's diet and given the fact that most individuals ought to reduce sodium intake to avoid hypertension, we suspect that his sodium levels fell within normal limits. Next, semi-regular consumption of apples, bananas, peppers, carrots and sandwiches which contained whole grain bread should have been a sufficient source of many vitamins and minerals. We can confidently conclude that our patient was not calcium deficient due to the very frequent consumption of nonfat vanilla yogurt (55 individual servings over the 4-week period). Lastly, we make particular mention of the fact that our patient consumed a multivitamin preparation that contained a wealth of vitamins and minerals, so it is unlikely that he is markedly deficient in any one in particular. Given the northern climate, winter season and indoor-sedentary lifestyle, many in his position are mildly to significantly deficient in vitamin D . Although, the RDA for vitamin D is 1000 IU, many physicians in northern climates suggest 2000 IU per day during the winter months. Since our patient took 5000 IU vitamin D supplement anywhere from 2 to 5 times a week, it is unlikely that he is deficient. In fact, we advise our patient to more carefully monitor his vitamin D intake since it is fat-soluble and can become toxic in excess amounts.

Our most significant criticism of our patient's diet is the relatively high proportion of processed snack bars. Over the 4-week period, our patient consumed a total of 68 Kind Fruit and Nut Bars, averaging over two bars a day. Although these bars contain 20% of the RDA for vitamin A, C and E, each contained 14 g of refined sugar, which has no nutritional value other than its caloric content. Additionally, There were many instances where one or two bars would replace an entire meal (e.g. breakfast). We highly recommend against this practice, largely because forgoing breakfast extends the fasting period, which may disturb blood glucose balance and insulin output and increases the risk of hypoglycemia. Furthermore, there is increasing evidence that shows that increased frequency of habitual breakfast is consistently positively associated with academic performance [1]. Although our patient did not technically skip

breakfast, we would like to see him modify his breakfast routine to include high-fiber whole grains and fruit (or vegetables), some protein-rich foods, such as milk and yogurt, and some healthy fats such as peanut butter and nuts.

Per his reports, our subject often only consumed one significant meal per day, which is also evidenced by the maximum average caloric intake between 4:00 and 5:00 pm. During the follow-up interview, our patient stated that, on most days, since he attended class from 9:30 am to 2:30 pm and often slept until 9:00 am to avoid excessive sleep debt accumulation, he wasn't able to eat a proper meal until the college's dining hall reopened for dinner at 4:30 pm. The number of meals often rose to at least two on the weekends when unstructured time and opportunity for exercise also increased.

Given the low frequency of cafeteria mealtimes, it is quite remarkable that our subject was able to maintain an average daily fasting interval of 2h 17m and an overall fasting time of just 5h 7m. He was able to do this, despite a busy schedule, through consistent and frequent snacking. There were a few instances when our patient consumed a Kind Fruit and Nut bar as often as every hour as he made transitions between classes. We would expect his blood glucose levels to peak approximately 1 hour after eating and then decrease as tissues oxidize glucose or convert it to storage forms of fuel. By 2 hours after a meal, his blood glucose levels would return to the fasting range (between 80 and 100 mg/dL). Therefore, over the course of an average day, we would expect to observe cyclic and gradual increases and decreases in blood glucose levels every 2 hours, with the levels mostly remaining within the boundaries of the normal fasting range. Since insulin secretion by the pancreas tends to follow blood glucose levels, we would expect to observe a similar trend in insulin levels. Lastly, since almost every meal/snack contained a significant carbohydrate component, we would expect to observe elevated glucagon

levels (and low insulin levels) only during overnight fasts, when our patient would go as long as 12 hours without consuming food.

In terms of a balanced diet and adequate exercise, Tuesday, February 9 was particularly well done. Our patient began the day with a balanced breakfast: an egg omelet with a toasted whole grain bagel and nonfat yogurt. Over the course of the day, he logged a total of 52 active minutes walking close to 6 miles. This day was particularly special because his energy expenditure was balanced (to within 150 kcal) by his caloric intake. In stark contrast, our patient was not as successful on 1/30/16, consuming 700 fewer calories than required by his BMR and burning close to 2000 more calories than he consumed. Following a high intensity weightlifting session from 12:00 pm - 3:15 pm, our patient consumed nothing but 2 servings of whey protein shake supplement, which would have been metabolically taxing and a strain on his body in it's attempt to maintain adequate blood glucose levels. Due to the high intensity workout, it is likely that liver and muscle glycogen stores were depleted through glycogenolysis, thus our patient would have had to rely on the glucose produced by the liver through gluconeogenesis to fuel neural tissue and red blood cells. Additionally, he would have had to draw upon fatty acids released from adipose tissue (through lipolysis) to fuel his muscles during and after exercise. Under such energy demanding conditions, we would also expect to see the breakdown of muscle protein to produce amino acids that can be used for gluconeogenesis. When questioned about his dietary choices on this day, our patient confirmed that this was not a reporting error and stated that he was unaware of the magnitude of his caloric deficit. He was advised against such practices as the continuation of days like these would be completely unsustainable in the long run.

RECOMMENDATIONS

Our primary recommendation to our patient is to increase his caloric intake, particularly because he at no time expressed the intention of a weight loss regimen and because his BMI already falls within the healthy range of 18.5 - 24.9 kg/m². Second, we suggest that our patient increase fluid and water intake - it appears that coffee, a caffeine containing mild diuretic, constituted a significant percentage of his total fluid consumption. Although caffeine does not inherently produce dehydration since the fluid loss due to increased urination is offset by the beverage itself, caffeine containing beverages are not ideal sources of fluids. Furthermore, our patient is not meeting the adequate intake of 9 cups (2.2 liters) of beverages a day as determined by the Institute of Medicine and listed by the Mayo Clinic [3].

Next, we would like our patient to increase his consumption of vegetables, fruits and grains. We recommend that at least four and one-half cups of vegetables and fruits be eaten each day, particularly green and yellow vegetables and citrus fruits. While our patient *does* consume some vegetables and fruits, it appears that he falls short on the four and one-half cups. Furthermore, we would recommend that our patient consume approximately 1.5 *more* ounces of whole grain products to meet the three or more ounce equivalent recommendation.

LITERATURE CITED

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