Tune-In To Your Ratio!

by Gary Scheiner MS, CDE

No, it's not a typo. Using insulin-to-carb ratios can give you meal flexibility and better blood glucose control.

Back in July/August, DSM ran an article, "Getting Down to Basals", extolling the virtues of background/basal insulin in blood sugar regulation. Granted, it was a fine article (by a first-rate author), but it failed to cover some rather important issues for those who take insulin. You see, basal insulin would meet our needs just fine… if we never ate. But we do eat, and food happens to make our blood sugar go up, and UP, and sometimes even **UP**.

What is it in food that makes the blood sugar rise? For the most part, *carbohydrate*, our bodies' preferred source of energy, is the culprit. Carbohydrates include sugars, starches and fiber, albeit fiber does not digest fully and hence does not raise blood sugar levels. Carbohydrates are found in most starchy foods (breads, cereals, potatoes, rice, pasta, beans) as well as fruits, juices, milk, sweets, and to a lesser extent, non-starchy vegetables.

What about fat and protein? Fat's direct impact on blood glucose levels is minimal. However, consumption of large amounts of fat can produce a temporary state of insulin resistance, as is commonly seen in those with Type-2 diabetes. Insulin resistance can cause a gradual blood glucose rise over a period of many hours. Protein's effect on blood glucose is minimal when it is included as part of a complex meal. But when protein is consumed in the absence of carbohydrates, upwards of 50% of the protein may be converted into glucose within a few hours, resulting in a moderate blood sugar rise.

Since it is uncommon for most of us to consume purely protein or excessive amounts of fat in a meal, we will focus our discussion squarely where it belongs: offsetting the impact of carbohydrates on blood sugar levels.

Covering the Carbs

The insulin given to offset the rapid rise induced by dietary carbohydrates is called "bolus" insulin. A bolus represents a quantity of rapid-acting insulin delivered at meal and snack times.

As was the case with basal insulin, appropriate bolus insulin dosing requires individualization and adjustment. It should be obvious that different amounts of carbohydrate require different amounts of bolus insulin. For this purpose, we use something called an "insulin-to-carb (I:C) ratio". The I:C ratio specifies how many grams of carbohydrate are covered by each unit of rapid-acting insulin. For example, a 1

unit-per-10-grams-of carb (1:10) ratio means that one unit of insulin covers 10 grams of carbohydrate. A 1:20 ratio means that each unit covers 20 grams. Calculating a meal or snack bolus becomes simple when your I:C ratio is known. Simply divide your carbs by your ratio. If each unit covers 10g and you consume 65 grams, you will need 6.5 units of insulin (65/10 = 6.5).

Note that using an I:C ratio of 1:10 will mean giving a larger bolus than if you use a ratio of 1:15. A 30g snack will require 3 units if using a 1:10 ratio, but only 2 units if using 1:15. As the second number in the ratio goes up, the amount of insulin goes down.

The beauty of an I:C ratio is that it gives you the flexibility to eat as much or as little carbohydrate as you choose while still maintaining good blood sugar control. It is common to require different I:C ratios at different times of day due to changes in hormone levels (which affect insulin sensitivity), physical activity (which enhances insulin sensitivity) and the amount of basal insulin overlapping with the bolus. For most people, insulin sensitivity tends to be a bit lower in the morning than later in the day. For example, I require a 1:10 ratio at breakfast, 1:12 at lunch, and 1:15 at dinner and in the evening.

Setting I:C Ratios

Two methods exist for determining initial I:C ratios. Whichever method you choose, it is best to begin with a conservative approach in order to prevent hypoglycemia.

The 500 Rule

This approach is based on the assumption that the average person consumes (via meals and snacks) and produces (via the liver) approximately 500 grams of carbohydrate daily. By dividing 500 by the average number of units of insulin you take daily (basal *plus* bolus), you should get a reasonable approximation of your I:C ratio.

For example, if you take a total of 25 units of insulin in a typical day, each unit of insulin should cover approximately 20 grams of carbohydrate (500/25 = 20). If you take 60 units daily, your I:C ratio would be 1 unit per 8 grams of carb (500/60 ≅ 8).

Avg. Units Insulin Daily (basal + bolus)	Approx. I:C Ratio
8-11	1:50
12-14	1:40
15-18	1:30
19-21	1:25
22-27	1:20
28-35	1:15
36-45	1:12
46-55	1:10

56-65	1:8
66-80	1:6
81-120	1:5
>120	1:4

The obvious weakness to this approach is that it assumes that all people eat about the same amount of food and produce the same amount of glucose each day. Those who are heavy or tend to eat relatively large amounts of carbohydrate will underestimate their insulin requirement with this approach; those who are lean, active or eat relatively little will overestimate their requirements.

The Weight Method

This approach is based on the supposition that insulin sensitivity diminishes as body mass increases; hence each unit of insulin will cover less carbohydrate in a heavier person than in a lighter person.

Weight (lbs)	Approx. I:C Ratio
<60	1:30
60-80	1:25
81-100	1:20
101-120	1:18
121-140	1:15
141-170	1:12
171-200	1:10
201-230	1:8
231-270	1:6
>270	1:5

One of the potential problems with this system is that it fails to consider body *composition*. An individual who weighs 250 lbs but is very muscular will be much more sensitive to insulin than a person of similar weight who has a great deal of body fat. It also fails to account for the degree of insulin resistance that may be present, particularly in those who have Type-2 diabetes.

Fine-Tuning and Verifying I:C Ratios

It is best to establish your basal insulin levels before attempting to fine-tune your mealtim boluses. Any basal insulin changes made after fine-tuning your boluses will require additional bolus adjustments.

Fine-tuning bolus ratios is best done empirically (through “trial and error”). Verify the I:C ratio at each meal and snack separately, as they can vary considerably.

Keep detailed written records when testing your I:C ratios. Track your blood sugar level before each meal and then again 3-4 hours later (to give the insulin a chance to work

fully) with no other food, exercise or boluses between the two blood sugar readings. It is best to eliminate factors other than food that might be affecting the results of the tests. For example, do not include data collected during or immediately after strenuous exercise. Also, don't count data collected during an illness or major emotional stress, at the start of a menstrual cycle or after a low blood sugar. Meals with very high fat content or unknown carb content (such as restaurant meals) should not be used as part of your analysis.

Because strange things can happen on any given day, I like to consider 10-14 days of data when coming to a decision regarding the I:C ratio. For example, consider the following:

Date	Pre-Breakfast Blood Sugar	Carbs	Bolus Insulin	Pre-Lunch Blood Sugar	Conclusion
6/1	175	50	6.5	101	A 1:8 ratio (50/6.5) makes Blood Sugar drop
6/2	83	50	4.0	78	1:12 held BS steady
6/3	62	75	5.0	226	Don't count – low to start
6/4	151	50	6.0	93	1:8 makes BS drop
6/5	210	40	6.0	113	1:7 makes BS drop a lot
6/6	75	75	5.0	180	1:15 makes BS rise
6/7	123	50	5.0	86	1:10 makes BS drop a bit
6/8	99	125	9.0	52	1:14 makes BS drop ???
6/9	97	30	2.5	114	1:12 held BS steady
6/10	154	65	3.0	274	1:20 makes BS rise a lot
6/11	295	20	7.0	65	1:3 makes BS drop a lot
6/12	168	60	5.0	171	1:12 held BS steady

Based on this information, I would be tempted to assign an I:C ratio of 1 unit per 12 grams of carb. An I:C ratio of greater than 1:12 tends to produce a blood sugar rise; less than 1:12 tends to produce a drop. When used, 1:12 held the blood sugar fairly steady – the lunch readings were within 30 mg/dl of the breakfast readings. I would throw out the data on 6/3 due to the low reading prior to breakfast. I would also throw out the data on 6/8 -- it is inconsistent with every other result, and the meal was much larger than usual (a slow-digesting Grand Slam Breakfast perhaps?).

The Truth Is In The Details

Fine-tuning I:C formulas can be a challenging proposition, even for the most highly trained and experienced person with diabetes. The more detailed you keep your records, the better. You might discover a variety of factors that have a subtle influence on your blood sugar levels. Look for variations by day of the week, work/school schedules, time of the month, physical/recreational activities, changes in pump infusion sets or insulin vials/cartridges, injection/infusion sites, dining in vs. out, medication schedules, and even social engagements.

For instance, one of my patients, Betty, had high readings every Sunday at lunchtime, but normal readings the rest of the week. The reason? Most likely church. Betty is very passionate about prayer. The lack of movement (she sits for several hours) coupled with the adrenaline surge she gets from the service is likely producing a consistent blood sugar rise. The solution: use her usual 1:10 breakfast formula during the week, but increase to 1:6 on Sundays.

Another patient, Dan, was experiencing very inconsistent blood sugars prior to dinner despite having the same lunch each day and using a consistent 1:15 bolus ratio at lunchtime. In reviewing his records, we found that most of his dinnertime lows were preceded by morning workouts; most of his dinnertime highs were preceded by no workout. The solution: use 1:10 at lunch after sedentary mornings, but decrease to 1:20 following morning exercise.

Given the complexities of determining bolus formulas, it is worthwhile to have a second set of eyes look over your records. Don't hesitate to ask your physician or diabetes educator to review your data and help you to form reasonable conclusions.

Be sure to tune in to DSM* Ratio for more insightful articles on how to optimize the *timing* of your boluses and adjust for stress, exercise, and those occasional high & low readings!

* Diabetes Self Management Magazine

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