HOW TO GET THE RIGHT MEAL TIME INSULIN DOSE WITH TYPE 1 DIABETES

Diabetic™
MUSCLE & FITNESS

CARBOHYDRATE AND PROTEIN

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ABBREVIATIONS

AA = Amino Acid

ADP = Adenosine Di Phosphate

ATP = Adenosine Tri Phosphate

AUC = Area Under the Curve

BCAA = Branches Chain Amino Acids

Ca = Calcium

CGM = Continuous Glucose Monitoring

FFA = Free Fatty Acid

FPU - Fat and Protein Units

GDH = Glutamate Dehydrogenase

GI = Glycaemic Index

GL = Glycaemic Load

GLP-1 = Glucagon-like peptide-1

GIP = Gastric Inhibitory Polypeptide

GPCR = G-Protein Coupled Receptor

I:G = Insulin to Glucagon ratio

ICR = Insulin to carbohydrate ratio

MDI = Multiple Daily Injections

MUFA = Monounsaturated Fatty Acids

KATP = ATP-regulated potassium channel

mTOR = mammalian target of rapamycin

SFA = Saturated Fatty Acid

TCA = Tri-Carboxyl-Acid cycle

WHAT DOES THE PANCREAS DO WHEN CARBOHYDRATE AND PROTEIN ARE CONSUMED?

INSULIN

Put simply, the B-Cells secrete extra insulin to move AA and glucose into the cells for anabolism and storage. More insulin is secreted than you would expect from their individual insulin secreting effects. The same signals that were discussed above are in play here. But one of the key factors that increases insulin more than expected are.

A. Blood glucose and AA level starts to increase, therefore more glucose and AA enters the B-Cell. The B-Cell now has abundant glucose to speed energy production through glycolysis, and more AA substrates to ensure glycolysis runs at full capacity. Therefore the B-Cell energy state is very high, leading to rapid insulin secretion.

GLUCAGON

The A-Cells also increase Glucagon secretion, which is the opposite to the decrease caused by carbohydrate alone. The same signals that were discussed above are in play here for Glucagon. But one of the key factors to be mindful here of is.

B. Insulin is the trump card! Although the GIP increases A-Cells secretion of Glucagon, the negative regulation from the high level of insulin dampens the glucagon rise compared the protein only.

If this increase requirement is not met by the person with Type 1 Diabetes, what are the consequences?

C. Lack of insulin to move the necessary glucose from the blood into the cells.

D. The negative regulation of insulin on the A-Cells will not be as high as it should be. Therefore, higher glucagon levels will increase liver glucose output, especially after 3-4 hours after eating when the administered insulin is wearing off.

E. Combined this means a glucose level that goes high initially and stays high.

RESEARCH

In healthy subjects, ingestion of 50 g of protein as lean beef and 50g of pure glucose elicited a significant increase in insulin over four hours (55). The amount required was 127% of that required for 50g of pure glucose over four hours (55). Another study compared the insulin response when adding different protein sources (milk, cod, whey, and others) to white bread (100%). They found the increase in insulin response varied from 124- 190% extra. Another study found the addition of protein to carbohydrate elicited 166% of the insulin response compared to carbohydrate alone (100%) (58).

This evidence is strongly suggestive that when protein is added to carbohydrate, the increase in insulin requirement is higher than you would expect than just protein alone, which is 20-30%. The evidence suggests for healthy people the requirement for carbohydrate and protein combined, compared to carbohydrate alone (100%) is in the region of 130-190% over 5-6 hours.

A consistent finding in the research is that people with insulin resistance have an even greater synergistic effect compared to healthy people. One study took seventeen people with type 2 diabetes and got them to consume 50g of glucose as a baseline, and measured the insulin response over the next five hours (24). They repeated the experiment several times, but added 25g of different proteins (beef, turkey, gelatin, egg white, cottage cheese, fish, and soy). The insulin secretion for glucose (50g) & cottage cheese (25g protein) was 360% vs. 100% for glucose alone. The lowest increase was that of egg white at 190%.

The person with type 1 diabetes who has also experiences insulin resistance needs to be mindful of this.

WHAT ABOUT RESEARCH ON PEOPLE WITH TYPE 1 DIABETES?

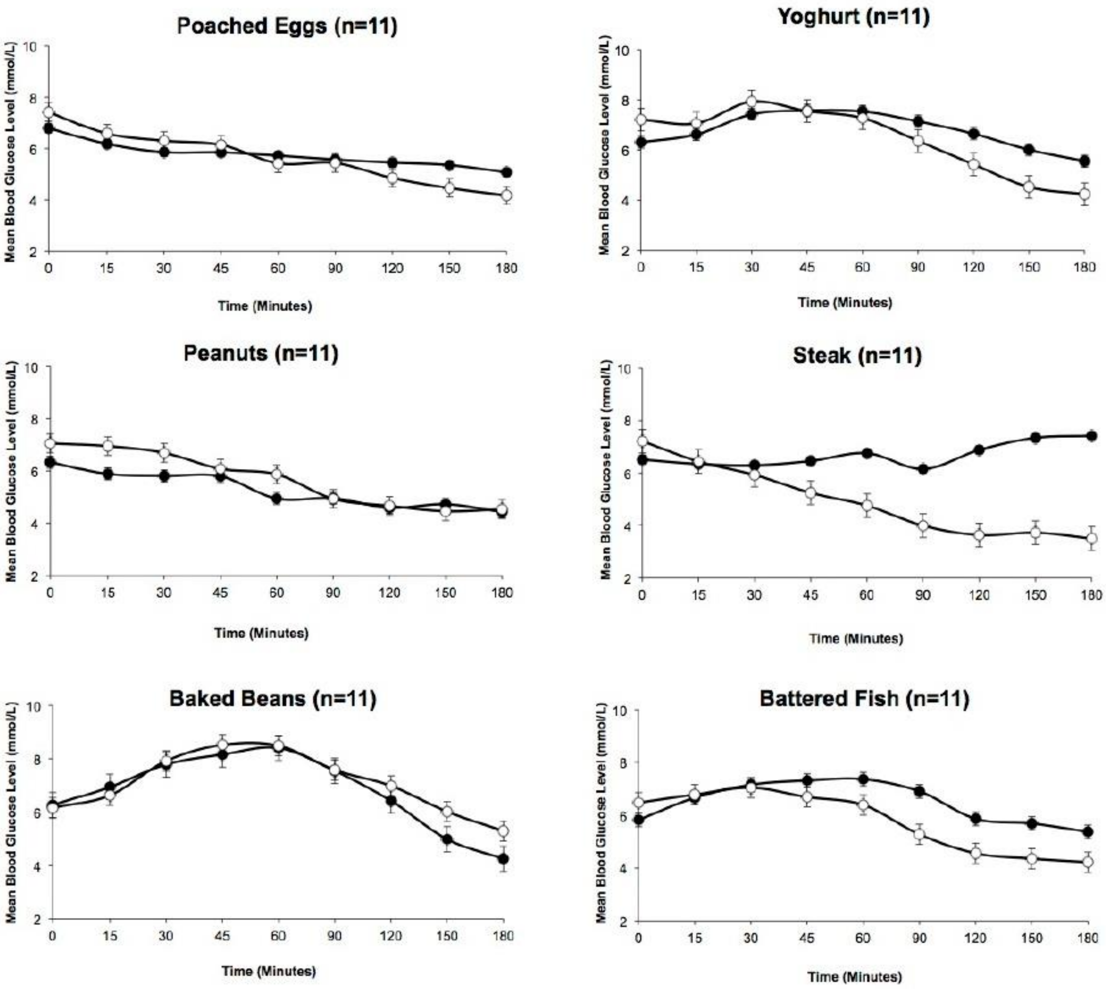
Research on children with Type 1 diabetes shows increasing protein from 5g to 40g protein for a 30g carbohydrate meal increased the glucose level at three hours by 2.4mmol/l. The glucose level stayed elevated at five hours by 2.6mmol/l, when compared to 30g of carbs alone (15). This suggests that extra insulin was needed in the first three hours.

Other studies report similar effects, where meals containing 28-57 g of additional protein have demonstrated significantly higher postprandial glycaemic excursions and insulin requirements in the two to five hour postprandial period in type 1 diabetes (35- 37).

As discussed in the fat and protein section, the FII study grouped looked at insulin dosing for high protein high carb foods. They compared the insulin dosing of carbohydrate counting vs. FID. The doses suggested are presented below, along with the percentage extra suggested by the FID:

- Low fat straw yoghurts, 5.4untis for carb counting vs. 6.9units for FID (28% extra).
- Baked beans, 4.3 units vs. 5.9units for FID (37% extra).
- Battered fish, 1.6units vs. 3.7units for FID (130% extra).

The results showed the FID insulin dosing had significantly lower average glucose level over three hours, with no difference in hypoglycaemia. The graphs below confirm the extra 28-130% extra insulin for high protein and carbohydrate foods is needed compared to carb counting alone.



Copied from Bell (70)

The FII group (70) used commercially available nutritional information to calculate the most effective algorithm for predicting the insulin response over two hours. A multiple regression algorithm was used on the 147 FII foods. The strongest performing formula could explain 50% of the insulin variance. That formula was:

FII = 10.4 + (1.0 Carbohydrate) + (0.4 Protein)

One must remember the FII only measures insulin requirement over two hours ,and we know the effect of protein lasts much longer than that. Therefore this is likely a substantial underestimation.

SUMMARY

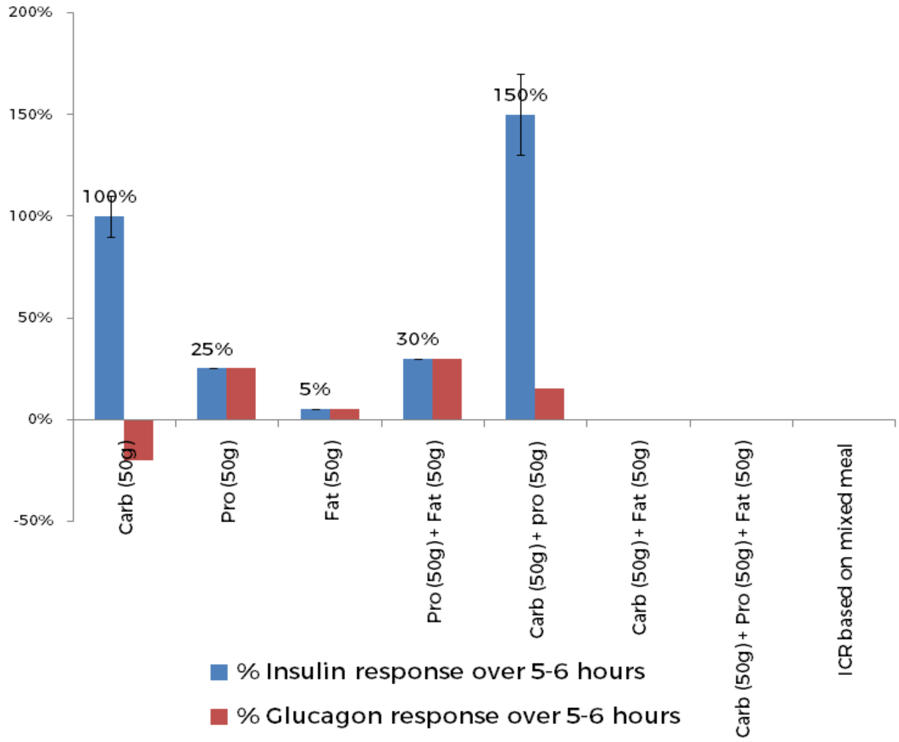
Very simply, when carbohydrate and protein are consumed both at 50g, the insulin increases more than would be predicted from their individual effects. The main factor is the synergy of AA and glucose in the B-Cell leading to a very high energy sate and insulin secretion. Glucagon only slightly increases, therefore the I:G is increased significantly. This allows anabolism and glucose storage as glycogen.

The job of the person with Type 1 Diabetes is to match the amount of insulin the pancreas would release for carbohydrate and protein. The main risk is too little leading to substantial hyperglycaemia, but too much would cause hypoglycaemia.

HOW MUCH INSULIN TO DELIVER FOR CARBOHYDRATE AND PROTEIN ON A GRAM BASIS?

The research suggests compared to carbohydrate alone (100%), the insulin requirement for carbohydrate and protein together is between 130-190%, dependant on type of protein. The FII data over two hours suggests you need to account for 40% of each gram of protein, but this is likely an underestimation of the total requirement over 5-6 hours.

The data suggest the average insulin requirement is about 150% for carbohydrate and protein, when compared to carbohydrate alone. For Glucagon, a slight increase from baseline of about 15%. Both are represented in the graph below. There is a 20% error bar included to accommodate the discussion on type of protein in the coming section. To keep it simple, dairy protein that is high in Leucine requires more insulin that foods lower in leucine.



For carbohydrate and protein meals, the best fit equation seems to be:

Insulin load = (protein (g) x 0.5) + (g) carbohydrate

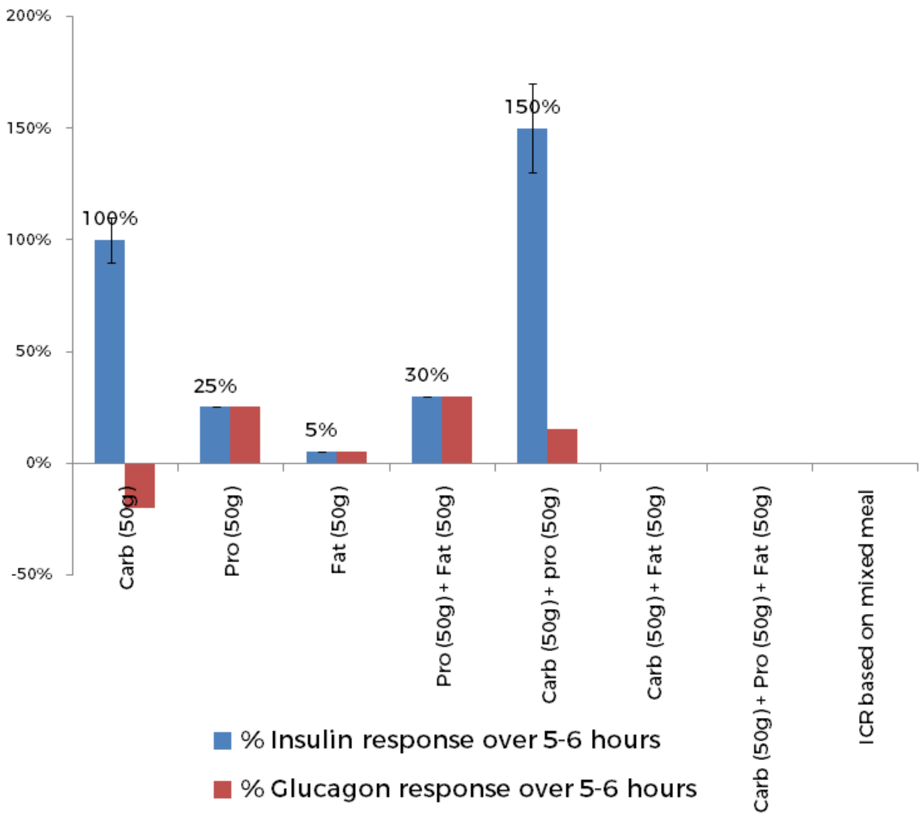
The Type 1 Diabetes research discussed above suggests the increase insulin requirement when protein is added to carbs is mostly in the first three hours (28). Therefore it would not appear necessary to split or delay the insulin delivery.

WHY DO MOST PEOPLE WITH TYPE 1 DIABETES NOT DO THIS?

Most people with Type 1 diabetes who carb count do not see the effect of usual protein intake on blood glucose level for a very important reason you **MUST** understand:

- When they work out there ICR, it is always on a mixed meal that contains their usual amount of carbs, protein, and fat. Unfortunately they believe they are only giving insulin to cover the effect of the carbohydrate. Whereas in reality, they are covering the effect of their usual mixed macronutrient meals. Have you ever tested and ICR using only bread? or did you have meat, fish, cheese, or butter on it?

- To help you picture this, look at the graph below. We will discuss later why the ICR covers about 130% of the effect of carbohydrate only. Just realise the ICR is more like a usual mixed meal ratio, that is mostly influenced by carbohydrate.



Times when protein and carbohydrate combinations present a problem:

- Change breakfast on a Sunday from typical cereal to a full English breakfast (Toast, Beans, mushrooms, sausage, eggs, bacon). Give the insulin for the toast only and end up with a very high glucose level.

- Large Steak with potatoes and bread

Bonus: Do all amino acids behave the same when combined with carbohydrate?

Certain AAs have been shown to have a more potent effect on increasing insulin secretion than others, when combined with carbohydrate. Leucine has consistently been shown to increase insulin secretion more than any other AA. In their series of studies Gannon and Nutall (26) showed a marked increase in insulin response for Leucine.

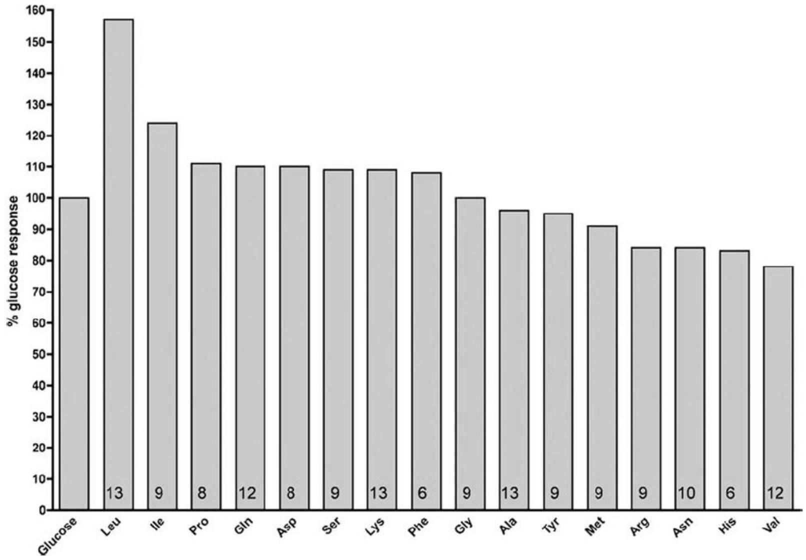


Figure 5. Insulin area response. % Individual amino acid + glucose compared to glucose alone. The mean insulin area response to glucose was set at 100%. The mean insulin area response to ingestion of the amino acid + glucose was divided by the mean area response to glucose alone to give a percentage. Numbers within the bars indicate the number of subjects studied.

Copied from Gannon &Nutall (26)

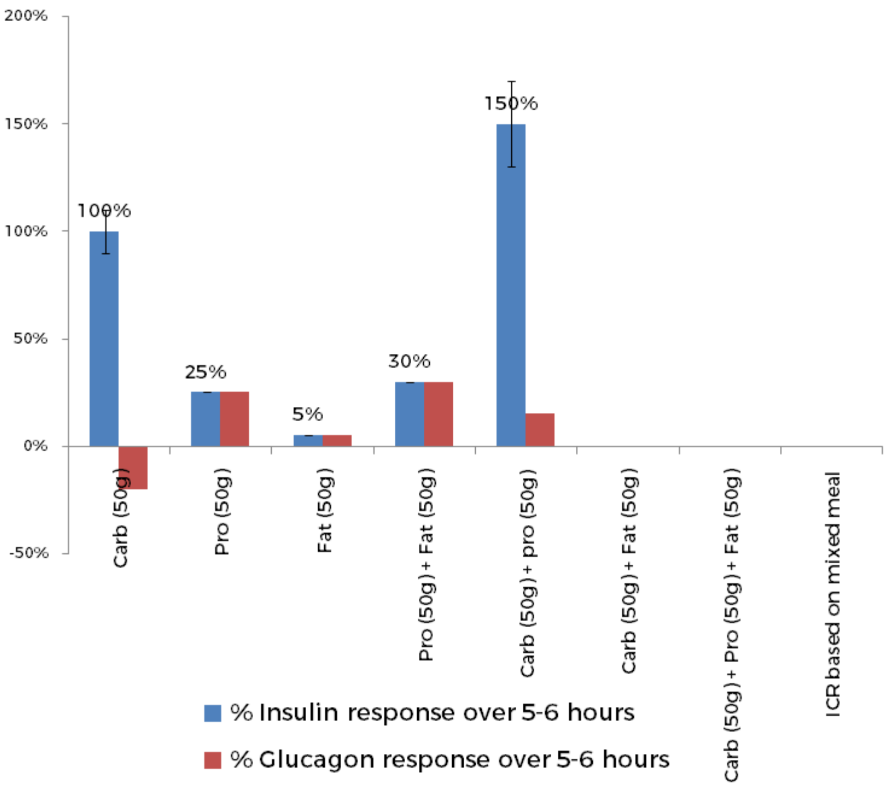
The mechanisms by which Leucine increases insulin secretion have been discussed previously. To jog the memory:

- Activating GDH in the B-Cell (61)
- Activation of MTOR in the B-Cell (63).

This helps explain why studies show whey protein, due to its rapidly absorbable Leucine, increases insulin secretion much higher than other protein sources (56). This may also explain the high FII scores for low fat dairy foods, such as of low fat yoghurt and skim milk. Analysis of the FII data reported that compared to all the AA, Leucine had one of the strongest correlations with insulin secretion (70).

This helps explain why people with type 1 diabetes often complain of very high post-prandial high glucose levels after breakfast cereal with Skim milk.

If you consume a diet that is high in milk based dairy products, or have a lot of whey protein, you may need to increase your insulin dose a little higher. This is represented in the 20% standard deviation bar shown that was added to the model we are building.



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