Counting fat and protein: A dietitian's perspective

Carmel Smart

Intensive insulin therapy and continuous glucose monitoring have been utilised by paediatric centres since the late 1990s. Typically, mealtime insulin doses are calculated by matching them to the carbohydrate contained in the meal. There is, however, increasing evidence that other macronutrients should be considered when determining bolus insulin dose and delivery. This article looks at the impact of fat and protein on postprandial blood glucose levels in children and young people with type 1 diabetes from the perspective of a dietitian. Alternative methods for calculating insulin doses for high-fat and high-protein meals are examined, and strategies for the management in clinical practice of meal composition outlined.

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Article points

1. Mealtime insulin doses for those receiving intensive insulin therapy have typically been based on carbohydrate intake.
2. There is increasing evidence that other macronutrients, such as fat and protein, affect postprandial blood glucose levels.
3. A number of insulin dosing algorithms have been developed, but more studies are needed.

Key words

- Fat and protein
- Intensive insulin therapy
- Macronutrients
- Type 1 diabetes

Since the late 1990s, intensive insulin therapy (IIT) has been utilised in paediatric diabetes centres worldwide. The use of IIT, as well as continuous glucose monitoring (CGM), has enabled elucidation of the effect of different meals on postprandial blood glucose levels (BGLs).

To date, the mealtime insulin dose has typically been calculated using an individualised insulin-to-carbohydrate ratio. However, there is increasing clinical evidence that the impact of other macronutrients should be considered when determining the bolus insulin dose and delivery.

Nutritional education

Carbohydrate counting

In day-to-day diabetes care, families are required to have an extensive knowledge of the carbohydrate amounts in foods. A study examining how accurately children and their care-givers estimated the carbohydrate content of commonly eaten meals found that children as young as 8 years could carbohydrate count with acceptable accuracy (Smart et al, 2010). However, other studies have reported that adolescents find carbohydrate counting challenging (Bishop et al, 2009), particularly with foods eaten away from home (Rankin et al, 2011).

It is our clinical experience at the John Hunter Children's Hospital, Newcastle, Australia that carbohydrate counting and the concept of matching prandial insulin dose to carbohydrate intake is best taught from diagnosis. In 2004, when carbohydrate counting was introduced as part of team-based diabetes education, our mean clinic HbA_{1c} fell from 68 to 62 mmol/mol (8.4 to 7.8%) and has now been in the range 57–58 mmol/mol (7.4%–7.5%) for the past 3 years.

Fat and protein

Once families have begun to master carbohydrate counting, then consideration of the effects of other macronutrients can be discussed. It is important to address the impact of high-fat, high-protein foods on postprandial BGLs (detailed below) as families otherwise may question their carbohydrate counting skills or unnecessarily avoid the food. The regular inclusion of high-fat or high-protein foods is not encouraged as part of a healthy diet. However, strategies to manage the occasional consumption of meals such as creamy pasta, fried fish and pizza are necessary.

Consider the continuous glucose monitoring traces in *Figures 1* and *2*. *Figure 1* depicts the trace of a 7-year-old pump user after consuming pizza on Tuesday evening, resulting in prolonged hyperglycaemia throughout the night. This was despite accurate carbohydrate counting. *Figure 2*

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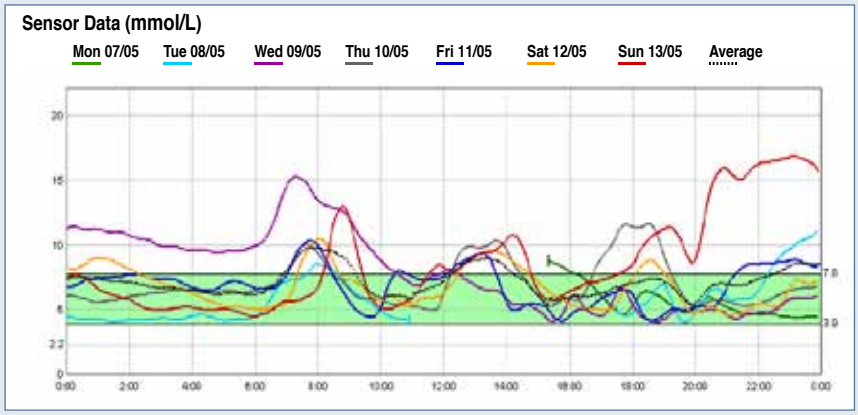

Figure 1. Continuous glucose monitoring traces of a 7-year-old insulin pump user. Following consumption of pizza on Tuesday evening, prolonged hyperglycaemia can be seen despite accurate carbohydrate counting.

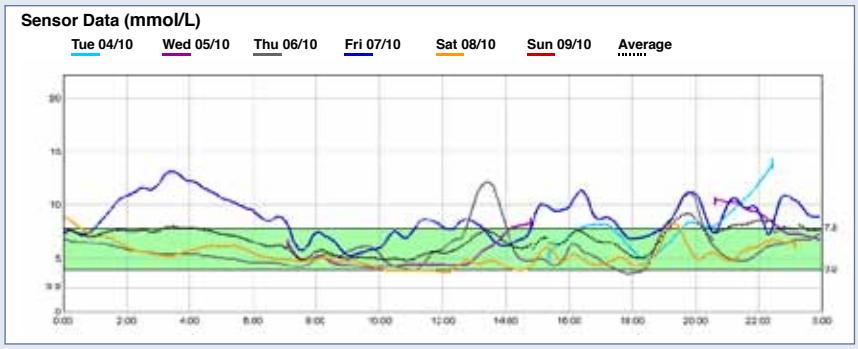

Figure 2. Continuous glucose monitoring traces of an adolescent using flexible multiple daily injection therapy. Note the delayed postprandial impact of fried chicken eaten on Thursday evening.

illustrates the delayed postprandial impact of fried chicken eaten on Thursday evening by an adolescent using flexible multiple daily injection (MDI) therapy. On the evenings when he ate family-based lower-fat meals, his BGLs stayed within target.

What is the impact of fat and protein?

Fat and protein have been shown to influence postprandial glycaemia in individuals with type 1 diabetes (Peters and Davidson, 1993; Lodefalk et al, 2008; Wolpert et al, 2013). However, there have been limited studies in children with diabetes.

A recent study conducted at the John Hunter Children's Hospital and Princess Margaret Hospital, Australia examined the separate and combined effects of high-fat and high-protein meals, all with the same carbohydrate content, on postprandial glycaemia in children using IIT (Smart et al, 2013). We found meals high in fat and protein increased glucose excursions from approximately 3 hours to 5 hours post-meal. Importantly, the effect of fat and protein were additive, resulting in significantly higher glucose excursions for high-fat, high-protein meals compared with meals of only high fat or high protein contents. This study provided supportive evidence that the amount of both fat and protein in meals should be considered in prandial insulin dosing.

Alternative methods for calculating insulin doses for fat and protein

In recent years, a number of novel insulin dosing algorithms have been developed to account for the glycaemic impact of fat and protein. These include the Warsaw Pump Therapy School (WPTS) formula, which calculates the insulin dose on the number of carbohydrate units (exchanges) and fat–protein units (defined as 100 kcal of fat or protein) (Pankowska et al, 2011), and the Food Insulin Index (FII), which is based on the physiological insulin demand evoked by foods in healthy subjects and then used to estimate the mealtime insulin dose in people with type 1 diabetes (Bao et al, 2011).

Currently, both methods have limitations and require further clinical trials before widespread adoption into clinical practice. A randomised controlled trial comparing the WPTS formula to carbohydrate counting alone found that postprandial hypoglycaemic episodes occurred more frequently in those using supplementary fat and protein counting (35.7%) compared with carbohydrate counting (9.5%; Kordonouri et al, 2012), which suggests the algorithm may over-calculate the insulin dose. Furthermore, evidence is needed to demonstrate that families can count fat, protein and carbohydrate in commonly eaten foods, as adherence has only been assessed by proxy measures such as the frequency of use of the dual-wave bolus (Pankowska et al, 2009). The use of the FII in children with type 1 diabetes requires clinical trials to demonstrate its effectiveness and potential use as an insulin dosing tool. Additionally, as FII dosing is based only on 2-hour postprandial insulin requirements, it may underestimate the insulin dose required for high-fat, high-protein meals.

Tips for the management of meals high in fat and protein in clinical practice

Strategies are needed to manage the delayed hyperglycaemia caused by meals high in fat and

protein. In clinical settings, the most relevant meal to consider is the evening meal as this can result in prolonged hyperglycaemia overnight. During the day most children will eat and, if necessary, give insulin to correct high BGLs every 3–4 hours.

From a practical viewpoint, if high-fat, high-protein meals are eaten only very occasionally, or after a day of increased activity, the glycaemic impact will be minimised.

Insulin pump therapy

An advantage of insulin pump therapy is the ability to tailor prandial insulin delivery to meal composition via the use of extended boluses. The dual-wave bolus has been shown to improve control of BGLs for up to 6 hours following meals high in carbohydrate and fat (Chase et al, 2002; Lee et al, 2004). Similarly, the dual-wave bolus is useful in decreasing the late postprandial hyperglycaemia experienced after eating pizza (Jones et al, 2005).

In clinical practice, some trial and error is required to determine the most appropriate insulin distribution in an extended bolus. Initially, commence with 50–70% of the insulin as a standard bolus and the remaining 30–50% as an extended bolus over 2–6 hours (Chase et al, 2002; Lee et al, 2004; Jones et al, 2005). Alter the split and duration according to postprandial BGLs. As discussed above, additional insulin may also be needed as part of the extended bolus. The amount of additional insulin requires individualised advice from the diabetes healthcare team.

Multiple daily injection therapy

For children and young people using MDI therapy, preprandial short-acting insulin, instead of rapid-acting insulin, may be helpful to control the delayed postprandial rise. Some clinicians advise that the meal bolus may be split. However, there is currently a lack of evidence to support this recommendation and it may increase the likelihood of some of the bolus insulin being forgotten. The best advice may be to factor in a small correction bolus later in the evening or overnight for meals that are high in fat and protein.

Conclusion

High-fat and high-protein meals cause delayed postprandial hypergycaemia in children using IIT. Adjustments to the mealtime insulin dose and distribution are necessary to prevent high glucose levels. However, consideration of the impact of fat and protein on postprandial BGLs involves the application of advanced nutritional concepts. These are best taught after basic nutrition knowledge, including carbohydrate counting, is established. Currently, the method of adjusting the insulin dose and distribution for meals high in fat and protein requires further study and may involve alternative methods to counting the fat and protein in a meal. As evidenced by our experience with families, fat and protein do not always need to be counted to achieve BGLs in target ranges. ■

"Consideration of the impact of fat and protein on postprandial blood glucose levels involves the application of advanced nutritional concepts."

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