The complex food counting system in managing children and young people with type 1 diabetes

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Article points

1. It has been hypothesised that, like the carbohydrate content of a meal, fat and protein raise blood glucose concentration.
2. A novel algorithm, the Warsaw Pump Therapy School formula, was developed to calculate the prandial insulin needs for a mixed meal.
3. With the right support, a complex carbohydrate, fat and protein counting system can help young people using an insulin pump to optimise their postprandial glycaemic control.

Key words

- Children and young people
- Complex food counting
- Type 1 diabetes

Authors

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For children and young people and their parents, achieving optimal postprandial glycaemic control is often a challenge even when the amount of carbohydrate contained in a meal is calculated carefully and the appropriate amount of insulin is administered. It has been hypothesised that it is not only carbohydrate products that lead to postprandial hyperglycaemia, but also the fat and protein content of a meal that raise the blood glucose concentration. Subsequently, a new algorithm for calculating the prandial insulin needs for a meal containing mixed macronutrients, the Warsaw Pump Therapy School (WPTS) formula, was conceived. This article reviews the evidence that the metabolic outcome in children and young people is affected when complex food counting and carefully calculated insulin dosages are applied.

Functional intensive insulin therapy represents a modern way of providing a flexible and effective therapy for type 1 diabetes in children and adolescents. In this approach to the control of blood glucose level, an individual's insulin-to-carbohydrate ratio (i.e. the number of grams of carbohydrate disposed of by 1 unit of insulin) is established. The correct prandial (or bolus) insulin dose for that individual is then calculated by multiplying their insulin-to-carbohydrate ratio by the number of 10-g portions (or exchanges) of carbohydrate contained in the meal to be consumed, a process commonly known as "carb counting". If an individual is hyperglycaemic before the meal, an additional correction dose is given.

Optimal postprandial glycaemic control is, however, frequently a challenge even in those children who have calculated precisely the amount of carbohydrates and the appropriate amount of insulin. Often after a favourite children's meal such as pizza, a prolonged blood glucose rise is observed, commencing 3–4 hours after the meal. This is frequently accompanied by a relative insulin resistance and can lead to uncertainty in the method and misleading interpretation of the cause of the hyperglycaemia.

Nowadays, insulin pump devices offer new opportunities for prandial insulin management. They provide three different ways of delivering insulin boluses: normal, square-wave and dual-wave. Using these kinds of boluses, it is possible to apply insulin in ways that correspond to the blood glucose curves that follow meals of different composition. Studies in people without diabetes, as well as in those who have the condition, have shown that the consumpion of food containing mainly carbohydrates leads to a rapid and short glucose rise, while fat and protein consumption is followed by a milder but prolonged increase in interstitial glucose concentrations (Ahern et al, 1993; Bao et al, 2011). High-calorie meals rich in carbohydrate, fat and protein produce a rapid and prolonged glucose rise.

Pankowska hypothesised that not only do the carbohydrate products lead to postprandial hyperglycaemia, but, in addition, the fat and protein content of the meal raise the blood glucose concentration up to 6 hours after the meal (Pankowska et al, 2012). Subsequently, the idea of a novel algorithm for calculating the prandial insulin needs for a mixed meal was conceived. According to this new algorithm, called the Warsaw Pump Therapy School (WPTS) formula, the insulin dose for the amount of carbohydrate in the meal is calculated and is delivered immediately as a quick bolus; the calculated dose for the fat and protein content is delivered in a modified extended bolus.

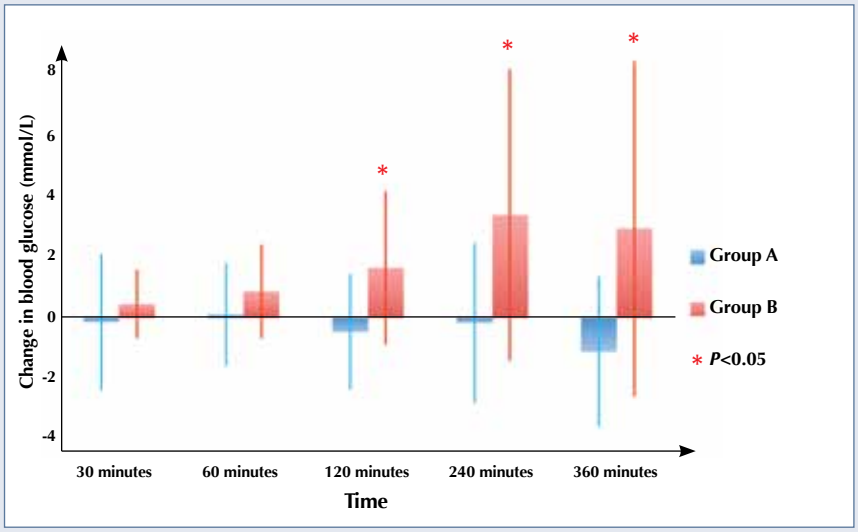

Figure 1. Change in postprandial blood glucose concentration following pizza meal over time (Δ–G) (mean±SD). Group A: experimental group, prandial insulin dose was delivered in dual-wave boluses according to the WSPT formula. Group B: control group, prandial insulin dose was applied according to carbohydrate counting in normal-wave boluses (Pankowska and Balzik, 2010).

The evidence of metabolic outcome with complex food counting

In several studies in young people with type 1 diabetes, Pankowska and colleagues tested the above-mentioned hypothesis. It has been shown that the use of the combined carbohydrate, fat and protein counting WPTS formula applied to a dual-wave bolus leads to significantly less blood glucose rise 2–4 hours after a pizza meal compared with conventional carb counting (*Figure 1*) administered with a standard bolus (Pankowska and Blazik, 2010). Another study group in Germany tested the WSPT algorithm in a randomised clinical trial in 42 individuals with long-standing type 1 diabetes and pump experience for at least 3 months and confirmed its beneficial effect after a pizza meal (Kordonouri et al, 2012). There was, however, a significantly increased rate of hypoglycaemia in the postprandial period.

Blazik and Pankowska (2012) incorporated complex food counting (carbohydrate, fat and protein) into the *Diabetics* software and analysed the effectiveness of the program in a 3-month prospective study. This randomised, open-label study involved 48 children aged 1–18 years. All individuals were educated in the food counting system according to the WPTS formula. The children were randomly allocated to an experimental group: A, who used Diabetics software, and a control group, B, who used calorie tables and mental calculations. Significant differences ($P<0.05$) were found between the groups concerning the 2-hour postprandial blood glucose values and the glucose variability parameters (*Figure 2*). At the end of the study, the HbA_{1c} decrease recorded in both groups probably related to additional patient education and more frequent blood glucose monitoring. In this study there were no significant differences in hypoglycaemic events, HbA_{1c} or insulin requirements. These results suggest that more insulin for a high-fat and high-protein meal does not represent a higher risk for hypoglycaemia.

The differences in the rate of hypoglycaemia incidence between the two studies in which the new algorithm was testsed are probably related to lower basal insulin ditribution in Blazik and Pankowska's study. It seems to be important to consider prandial insulin dosing together with basal insulin application.

Complex food counting in daily practice: Adherence level

The WPTS formula is a complex one and, particularly at the beginning, a time-consuming procedure. In order to analyse individuals' adherence, insulin administration data were taken from the memories of insulin pumps in a

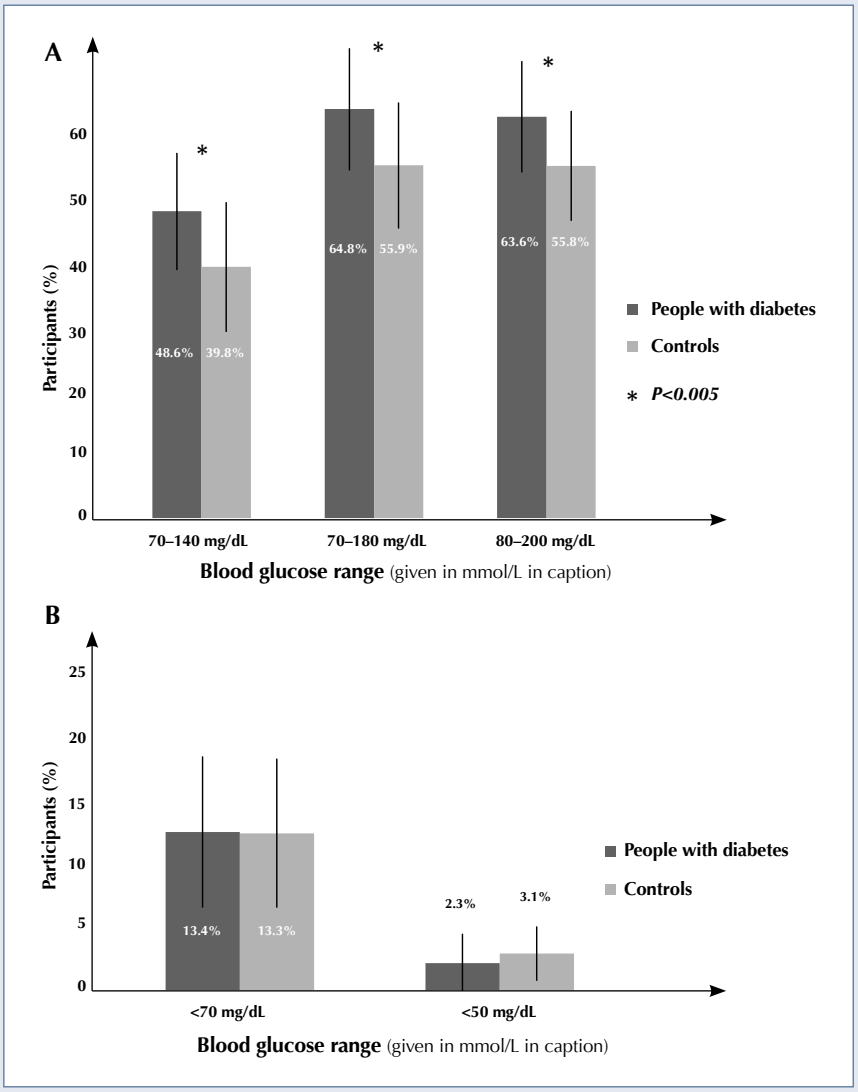

Figure 2. Percentage of blood glucose measurements by target ranges, recorded during the study period by self-monitoring blood glucose. (A) The percentage of postprandial blood glucose concentration by three target ranges: normal range, 70–140 mg/dL (3.9–7.8 mmol/L); near-normal range, 70–180 mg/dL (3.9–10.0 mmol/L); and above recommended range, 80–200 mg/dL (4.4–11.1 mmol/L). (B) The percentage of blood glucose records below 70 mg/dL (3.9 mmol/L) and below 50 mg/dL (2.8 mmol/L) during the study observation period (Blazik and Pankowska, 2012).

cross-sectional study that included the records of 499 people aged 0–18 years (Pankowska et al, 2009). Only 18.8% of the people did not use the WPTS formula at all. Young people who used this algorithm and the dual- or square-wave bolus in order to cover high amounts of fat and protein at least twice a day had significantly better HbA_{1c} values than those who were non-compliant with this strategy.

In a further study to assess adherence, Gajewska and Pankowska (2012) analysed the longitudinal data in 95 children and young people educated with the WSPT formula. Only three of 95 participants did not apply any dual- or square-wave bolus, 30 used it rarely and 62 applied it at least once a day. This third group of children was called "adherent" to the WSPT formula. In terms of HbA_{1c}, those with adherence to the WSPT formula kept their metabolic control in near-normal glycaemic ranges.

Conclusions

A complex food counting system combining carbohydrate, fat and protein counting and the application of an appropriate dual-wave insulin bolus can be helpful for young people using an insulin pump to optimise their postprandial glycaemic control after complex meals. It is important to note, however, that educational and practice sessions provided by specialised healthcare professionals are a prerequisite for the successful translation of fat and protein counting in real life. ■

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