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Insulin to carbohydrate ratios with increasing carbohydrate loads

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DECLARATION

I, Kerry Marran, declare that this research report is my own work. It is being submitted for the degree of Master of Medicine in the branch of Paediatrics in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other university.

Signed: _____

_____day of _____2010

PUBLICATIONS AND PRESENTATIONS ARISING FROM THIS STUDY

Marran K, Segal D, Balanco B, Lang A. Insulin to Carbohydrate ratios with increasing Carbohydrate loads. Poster session presented at: 3rd Annual Advanced Technologies and Treatments for Diabetes conference; 2010 Feb 9-13; Basel, Switzerland.

ABSTRACT

Background: To reduce the risks and prevent progression of diabetic complications average blood glucose and glucose variability need to be kept as close to the non diabetic range as possible. Post prandial glucose excursions contribute significantly to average blood glucose and to glycemic variability.

Dietary carbohydrate is the primary determinant of meal related blood glucose excursions. Carbohydrate counting is a method of insulin dosing that matches carbohydrate load to insulin dose using a fixed ratio. Many patients and current insulin pumps, calculate insulin delivery for meals based upon a linear carbohydrate to insulin relationship.

Hypothesis: A non-linear relationship exists between the amount of carbohydrate consumed and the insulin required to cover it. Rather, an exponential increase in insulin is needed to cover an increasing load of carbohydrate.

Aim: To document blood glucose exposure, as measured by AUC, in response to increasing carbohydrate loads on fixed carbohydrate to insulin ratios.

Sample and Methods: 5 Type-1 diabetic adolescents and young adults on insulin pump therapy with good control were recruited. Morning basal rates and carbohydrate to insulin ratios were optimized prior to the study start. A Medtronic glucose sensor was worn by each participant for 5 days on which standardized meals of increasing carbohydrate content were consumed. After the 5 days the glucose sensors were downloaded and the glucose area under the curve was analyzed for each carbohydrate load for each participant.

Results: Only subjects with 5 days of complete recordings covering the test meals were included for analysis, resulting in 5 complete analyses. Sensor failure and hypoglycaemic

episodes prior to test meals accounted for failures. Increasing carbohydrate loads on a fixed carbohydrate to insulin ratio resulted in increasing glucose area under the curve (AUC).The log (Average AUC) was linear confirming that this relationship is exponential. An Analysis of Covariance performed on the log (AUC) data confirmed a highly significant exponential relationship ($p<0.0001$) although no significant differences were found between the profiles of the 5 individuals. Late post prandial hypoglycaemia followed carbohydrate loads greater than 60 grams and this was often followed by rebound hyperglycaemia that lasted more than 6 hours.

Conclusion: A non linear relationship exists between carbohydrates consumed and the insulin required to cover them when using premeal bolus insulin. This has implications for control of postprandial blood sugars, especially when consuming large carbohydrate loads. Because of the late post prandial hypoglycaemia that follows the larger doses of insulin used with larger amounts of carbohydrate it is not possible to simply increase the amount of the insulin bolus using an exponential formula.

Further studies need to be done looking at the optimal ratios of insulin needed for increasing carbohydrate loads, the duration and type of boluses needed to cover these high carbohydrate loads and the possibility of changing the linear equation used in current insulin pumps to one that would better cover the increase in post prandial glucose load with large carbohydrate meals.

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NOMENCLATURE

PPBG	Postprandial blood glucose
HbA1c	Haemoglobin A1c = glycosylated haemoglobin
ADA	American Diabetes Association
GI	Glycemic index
“Carb”	1 Carb = 15g carbohydrate
CSII	Continuous subcutaneous insulin infusion = insulin pump therapy
MDI	Multiple daily injections
CGMS	Continuous glucose monitoring system
SMBG	Self monitoring blood glucose
AUC	Area under the curve