Demystifying Insulin Pump Therapy

Jacobus van Dyk
Paediatric Endocrinologist.

WHY?

DCCT (DIABETES CONTROL & COMPLICATIONS TRIAL)

OBJECTIVE

- Determine if **Intensive Therapy (CSII)** reduces long-term complications associated with diabetes versus **Conventional Therapy (MDI)**

DESIGN

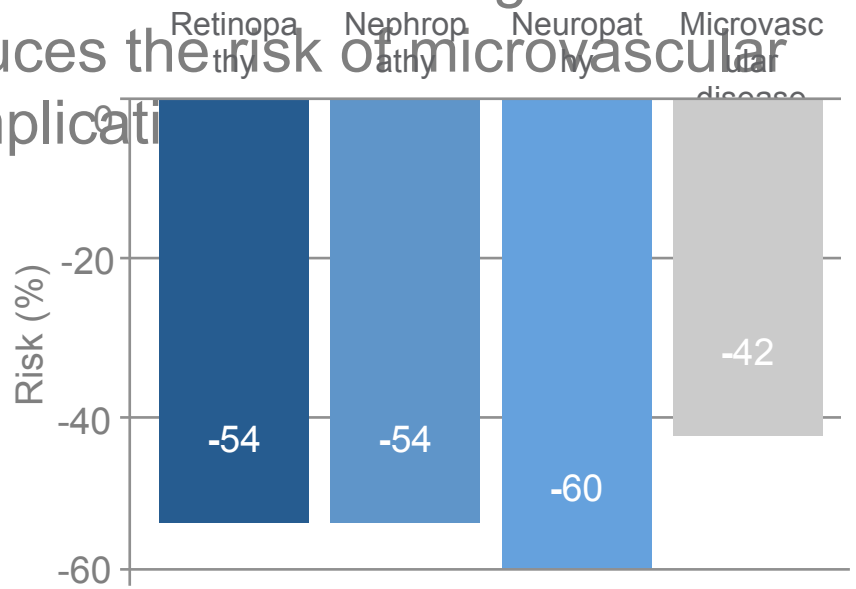
- 10 Year Study (n = 14041 patients)
- 2 Groups:
  - Conventional Therapy (1-2 injections/day)
  - Intensive Therapy (≥3 injections/day or Pump)

The Diabetes Control and Complications Trial Research Group. The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. N Engl J Med. 1993;329:977-986.

DCCT (DIABETES CONTROL & COMPLICATIONS TRIAL)

RESULTS

- Intensively treated patients achieved a mean A1C of 7.3%, compared with 9.1% for conventionally treated patients
- Good control of blood glucose levels reduces the risk of microvascular complicati



1.Diabetes and ocular disease : past, present, and future therapies / edited by Ingrid U. Scott, Harry W. Flynn Jr., William E. Smiddy.—2nd ed. Oxford University Press, Inc Copyright c 2010 by Ingrid U.Scott, Harry W. Flynn, Jr., and William E. Smiddy.
2. Skyler JS: Diabetic complications. The importance of glucose control. Endocrin Metab Clin N Amer. 1996; 25: 243-254.

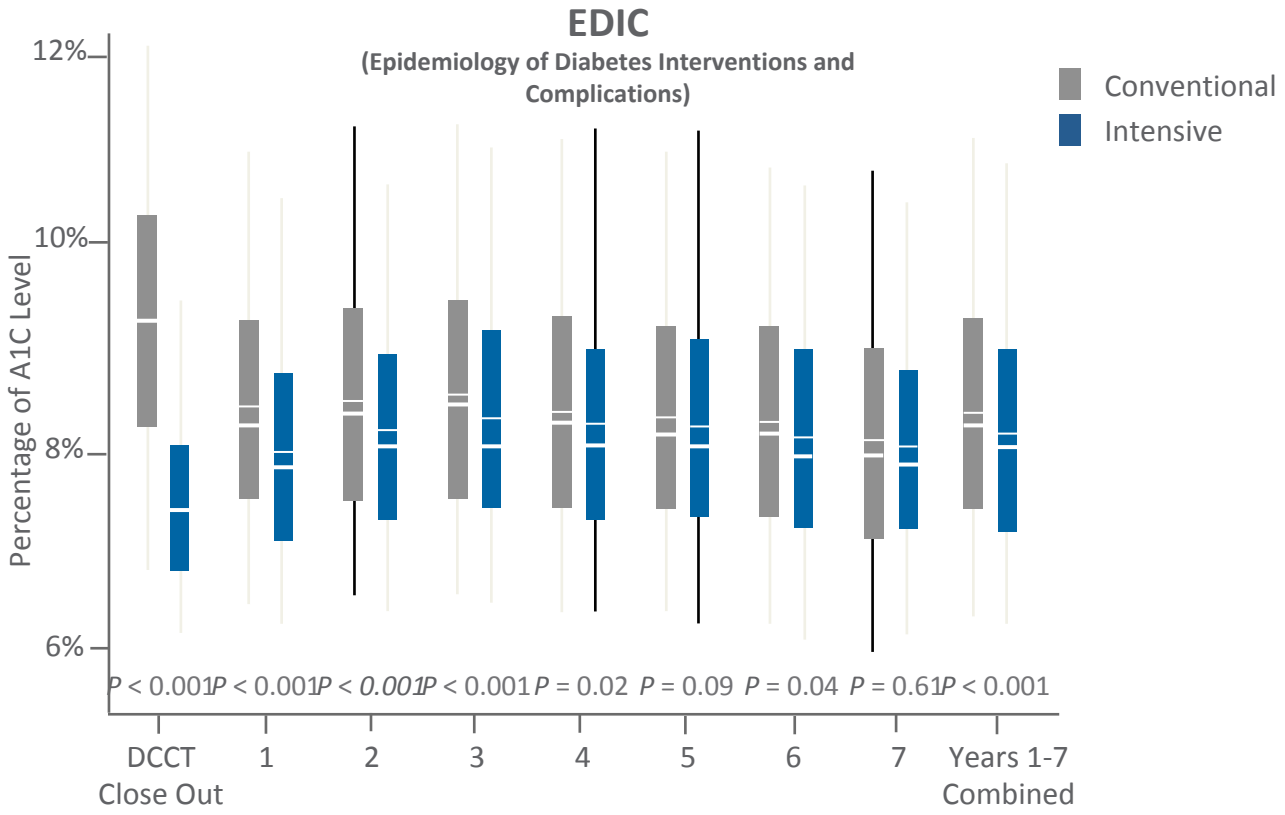
EDIC (Epidemiology of Diabetes Interventions and Complications)

- **OBJECTIVE**
  - 4 years after completion of DCCT
  - Effect of intensive therapy on the microvascular complications of type 1 diabetes mellitus

EDIC (Epidemiology of Diabetes Interventions and Complications)

RESULTS

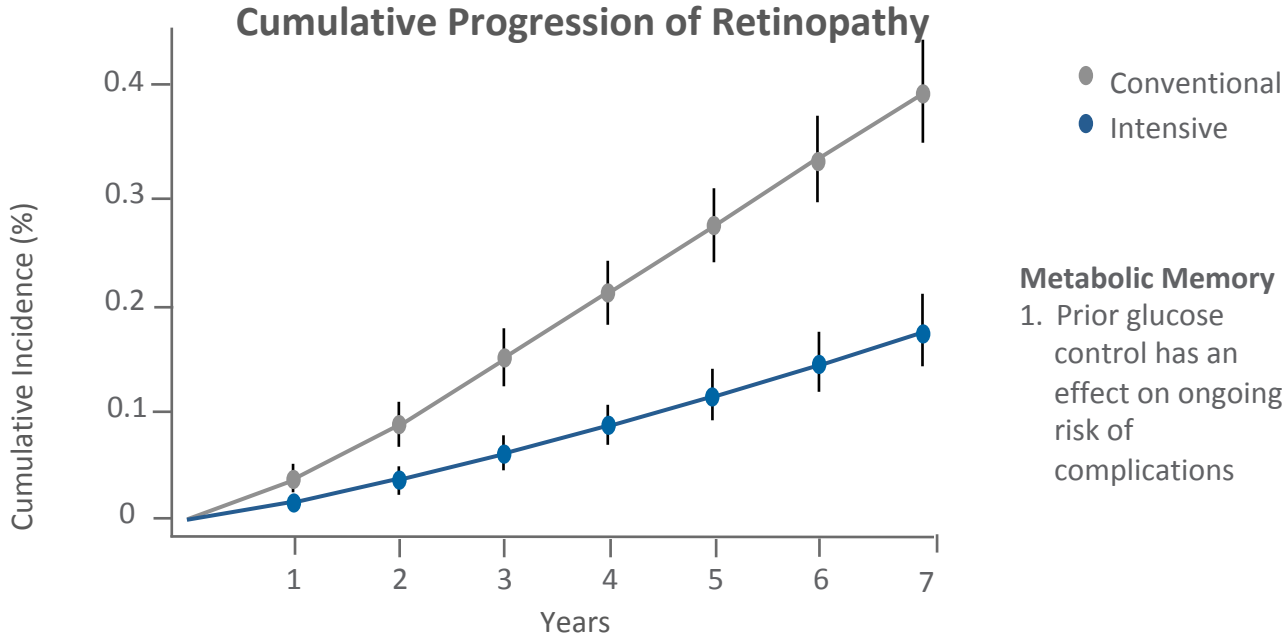
- 4 years after completion of DCCT



DCCT/EDIC. Effect of Intensive Therapy on the Microvascular Complications of Type 1 Diabetes Mellitus. JAMA 2002;287(19):2563-2569.

EDIC (Epidemiology of Diabetes Interventions and Complications)

- **RESULTS**
  - EDIC Supports Early Adoption of Intensive Therapy
  - Metabolic Memory / Legacy Effect



Metabolic Memory

1. Prior glucose control has an effect on ongoing risk of complications

No. Evaluated							
Conventional	169	203	220	581	158	192	200
Intensive	191	222	197	596	170	218	180

DCCT/EDIC. Effect of Intensive Therapy on the Microvascular Complications of Type 1 Diabetes Mellitus. JAMA 2002;287(19):2563-2569.

People with diabetes choose pumps for:

- A convenient and more normal lifestyle
- Flexibility in when and how much to eat
- Improved matching of insulin delivery to the body's variable needs
- Less hypoglycaemia and hypoglycaemia awareness

People with diabetes choose pumps for:

- Assistance with calculations.
- Data tracking required to achieve optimal control
- Improved balancing of exercise with insulin
- Freedom to travel or to perform shift work

Health professionals recommend pumps for:

- Sub-optimal control
- Dawn Phenomenon with elevated fasting blood sugars
- Frequent or severe hypoglycaemia or hypoglycaemia unawareness
- Night time hypoglycaemia
- Low insulin requirement

Health professionals recommend pumps for:

- Frequent travel & variable work schedule
- Intensive exercise or athletics
- Tracking insulin doses, carbs, glucose levels – critical to control
- Reminders

Health professionals recommend pumps for:

- Preventing, delaying or reversing complications
- Improving control during puberty
- Frequent DKA / hospitalizations
- Gastroparesis

Is a pump better than multiple injections?

Better insulin delivery

- With multiple injections the pump mimic the basal or back ground insulin
- Bolus doses to cover meals
- Correction boluses to correct BG

More convenience and flexibility

- Weekends and holidays.
- Prevent insulin stacking.

Is a pump better than multiple injections?

Greater precision

- Increments of 0,025 units (twenty five thousands of a unit) – prevent critical low BG levels

More reliable insulin action

- Specially the Lente, NPH and Ultra Lente insulin – 25% variability. New analogues better.
- Only with pump therapy basal delivery can be matched to needs like Dawn Phenomenon, changing waking or work hours or with strenuous exercise.

Is a pump better than multiple injections?

Easier problem solving

- Only ultra short acting insulin in the pump
- Easier to separate the basal and bolus effect

Less Hypoglycaemia with lower HbA1c

- Specially so with sensor augmented pump therapy
- Less hypoglycaemia unawareness.

Drawbacks to pumping

It is a mechanical device!

- Pumps use small computers to deliver sophisticated doses of insulin.
- Therefore requires a conscientious user to go through a learning curve in order to make it work properly.

A pump is not the answer for everyone!

CSII META–ANALYSIS: BENEFIT OF CSII VS MDI

- **OBJECTIVES**
- This **meta-analysis** aimed to evaluate the clinical effectiveness of CSII therapy in reducing **severe hypoglycaemia frequency** and **HbA1c levels**, as compared to MDI therapy.

- **DESIGN**
- • Meta-analysis of 22 RCTs or B/A studies
- • CSII vs MDI
- • CSII therapy duration between 6 to 48 months
- • 1414 subjects with Type 1 diabetes

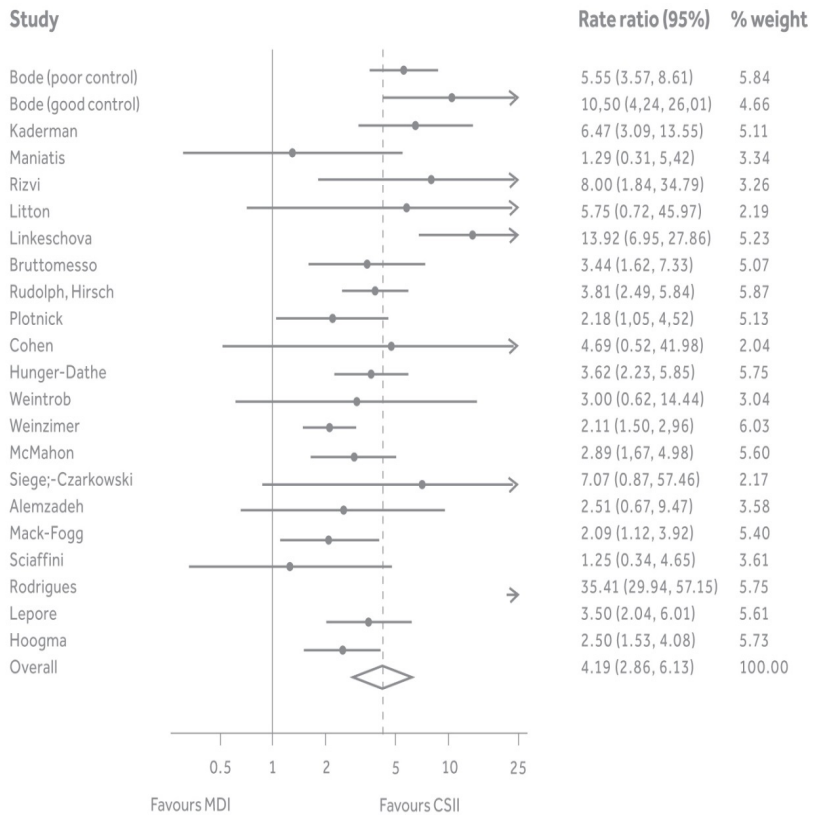
Severe hypoglycaemia and glycaemic control in Type 1 diabetes: meta-analysis of multiple daily insulin injections compared with continuous subcutaneous insulin infusion. Pickup J.C., Sutton A.J. Diabetes Medicine 25(7):765-774, 2008.

CSII META–ANALYSIS: BENEFIT OF CSII VS MDI

RESULTS

SH significantly and markedly reduced during CSII compared with MDI

FIGURE 1: Rate ratios of severe hypoglycaemic events between CSII and MDI



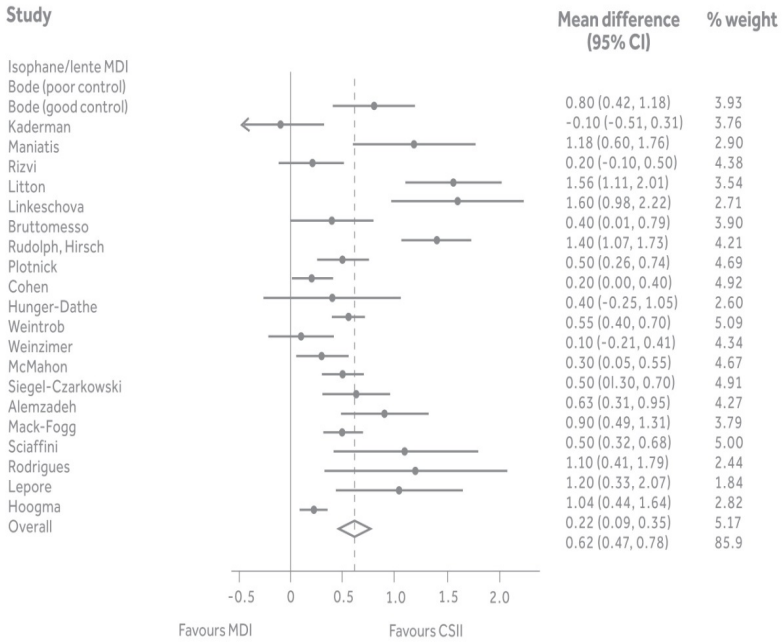
Long-term outcome of insulin pump therapy in children with type 1 diabetes assessed in a large population-based casecontrol study. Johnson SR, Cooper MN, Jones TW, Davis EA. Diabetologia 56:2392-2400, 2013.

CSII META–ANALYSIS: BENEFIT OF CSII VS MDI

RESULTS

- Significantly better control of HbA1c on CSII compared with MDI
- The mean **HbA1c level was 0.62% lower** with CSII therapy compared to MDI therapy (0.72% and 0.21% in B/A studies and RCTs, respectively)

FIGURE 2: Mean difference in HbA1c levels between CSII and MDI



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LONG TERM BENEFIT OF CSII IN CHILDREN COMPARED TO MDI

OBJECTIVES

- This study aimed to evaluate the long-term clinical effectiveness of CSII therapy in improving glycaemic control and **reducing severe hypoglycaemia** and **DKA hospitalisation** as compared to insulin **injection** therapy in children with **Type 1 diabetes**.

DESIGN

- Observational, retrospective case control study
- CSII versus MDI
- 7 year duration
- 345 children (aged up to 28 years)

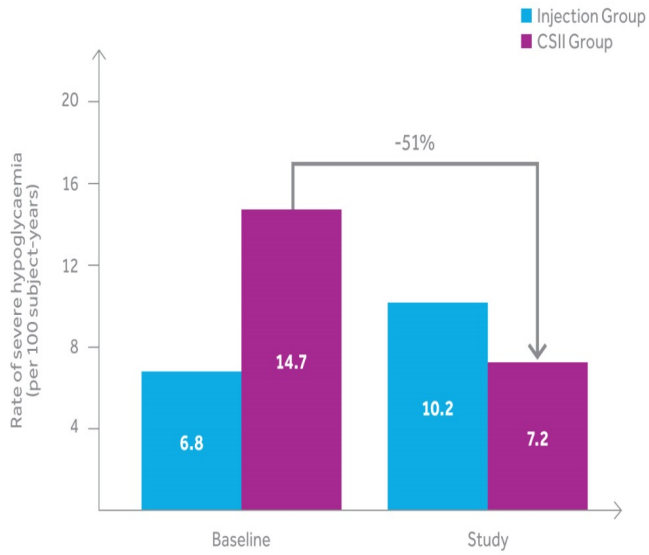
Long-term outcome of insulin pump therapy in children with type 1 diabetes assessed in a large population-based casecontrol study. Johnson SR, Cooper MN, Jones TW, Davis EA. Diabetologia 56:2392-2400, 2013.

LONG TERM BENEFIT OF CSII IN CHILDREN COMPARED TO MDI

RESULTS

- The rate of severe **hypoglycaemia was reduced by 51%** in the CSII group from baseline.
- In comparison, the rate of severe hypoglycaemia increased by 50% in the injection group

FIGURE 1: Rates of severe hypoglycaemia in injection group and CSII group



Long-term outcome of insulin pump therapy in children with type 1 diabetes assessed in a large population-based casecontrol study. Johnson SR, Cooper MN, Jones TW, Davis EA. Diabetologia 56:2392-2400, 2013.

Medtronic CareLink® Pro – Report Preview for Potgieter Dane generated on 2013/02/02 11:10:46 AM

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Sensor & Meter Overview (1 of 3) Potgieter, Dane

2012/12/07 - 2012/12/21

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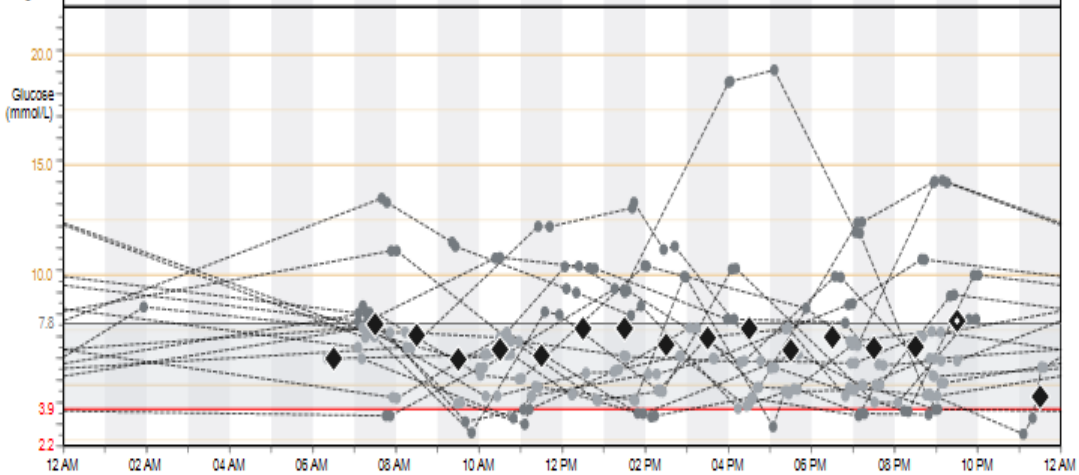
Data Sources: MiniMed Paradigm 715 (942509), OneTouch Ultra 2 (BLP0F77CY)

24-Hour Meter Glucose Overlay - Readings & Averages (mmol/L)

							Breakfast					Lunch					Dinner							
Readings	0	1	0	0	0	0	2	23	5	9	18	12	11	18	15	7	16	15	11	18	19	14	1	4
Avg BG	--	8.5	--	--	--	--	6.2	7.8	7.3	6.2	6.6	6.3	7.6	7.6	6.8	7.1	7.6	6.6	7.2	6.7	6.7	7.9	10.0	4.5



Statistics	12/07	12/21
Avg BG (mmol/L)	7.1 ± 3.0	
BG Readings	219	14.6/day
Readings Above Target	68	31%
Readings Below Target	21	10%
Sensor Avg (mmol/L)	--	
Avg AUC > 7.8 (mmol/L)	--	--
Avg AUC < 3.9 (mmol/L)	--	--

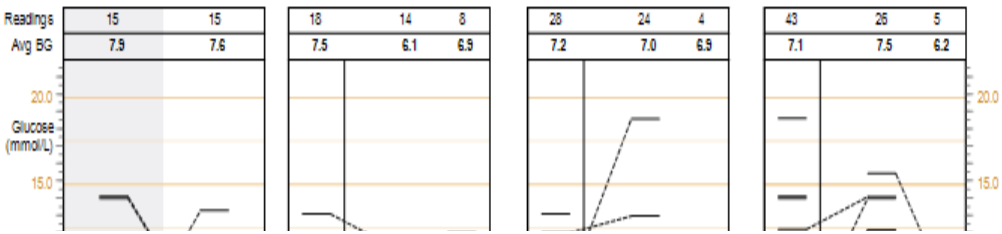
Avg Daily Carbs (g)	260 ± 22	
Carbs/Bolus Insulin (g/U)	12.0	

Avg Total Daily Insulin (U)	32.0 ± 1.8	
Avg Daily Basal (U)	10.3	32%
Avg Daily Bolus (U)	21.7	68%

Meter Glucose Overlay Bedtime to Wake-Up and Meal Periods – Readings & Averages (mmol/L)

Bedtime to Wake-up	Breakfast: 06:00 AM - 10:00 AM	Lunch: 11:00 AM - 03:00 PM	Dinner: 04:00 PM - 10:00 PM
Bedtime: 08:00 PM - 12:00 AM	Meals Analyzed: 19	Meals Analyzed: 31	Meals Analyzed: 47
Wake-up: 05:00 AM - 09:00 AM	Avg Carbs: 50g	Avg Carbs: 35g	Avg Carbs: 30g
	Avg Insulin: 5.4U	Avg Insulin: 2.5U	Avg Insulin: 2.2U
	Avg Carbs/Insulin: 9.1g/U	Avg Carbs/Insulin: 13.8g/U	Avg Carbs/Insulin: 13.3g/U

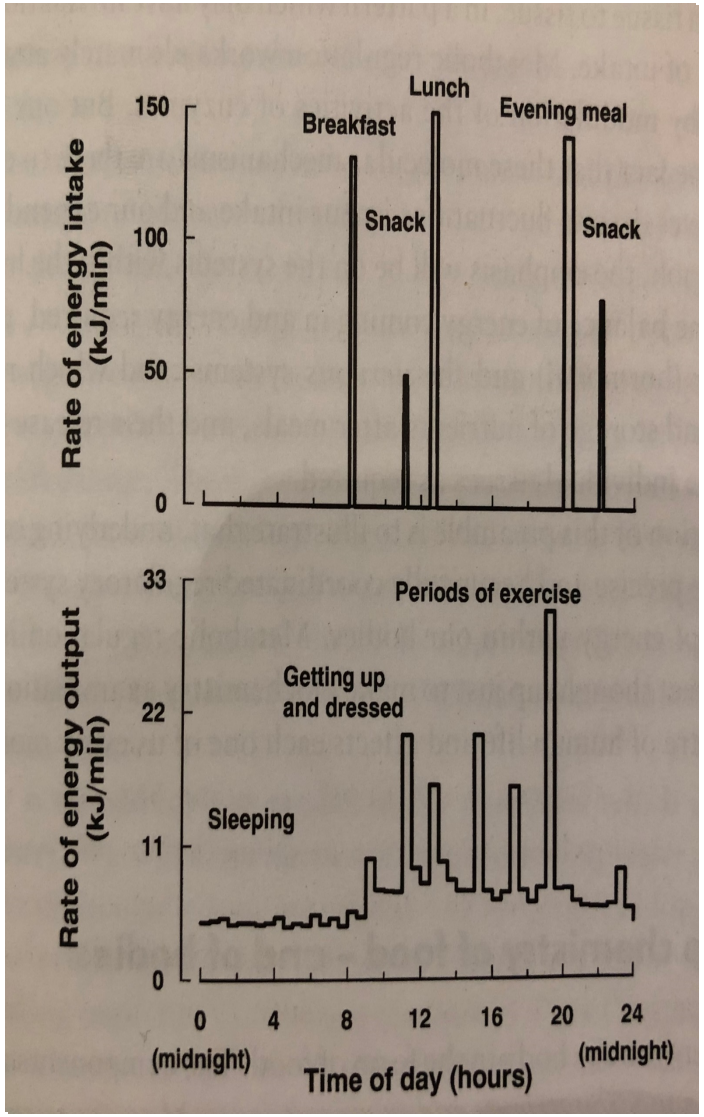
Readings	15	15	18	14	8	28	24	4	43	26	5
Avg BG	7.9	7.6	7.5	6.1	6.9	7.2	7.0	6.9	7.1	7.5	6.2



TO UNDERSTAND THE SETTINGS AND DELIVERING OF INSULIN, WE HAVE TO GO BACK TO THE NORMAL PHYSIOLOGY OF INSULIN AND CARBOHYDRATE METABOLISM

Metabolic regulation

Rates of energy intake and output for a person during a typical day



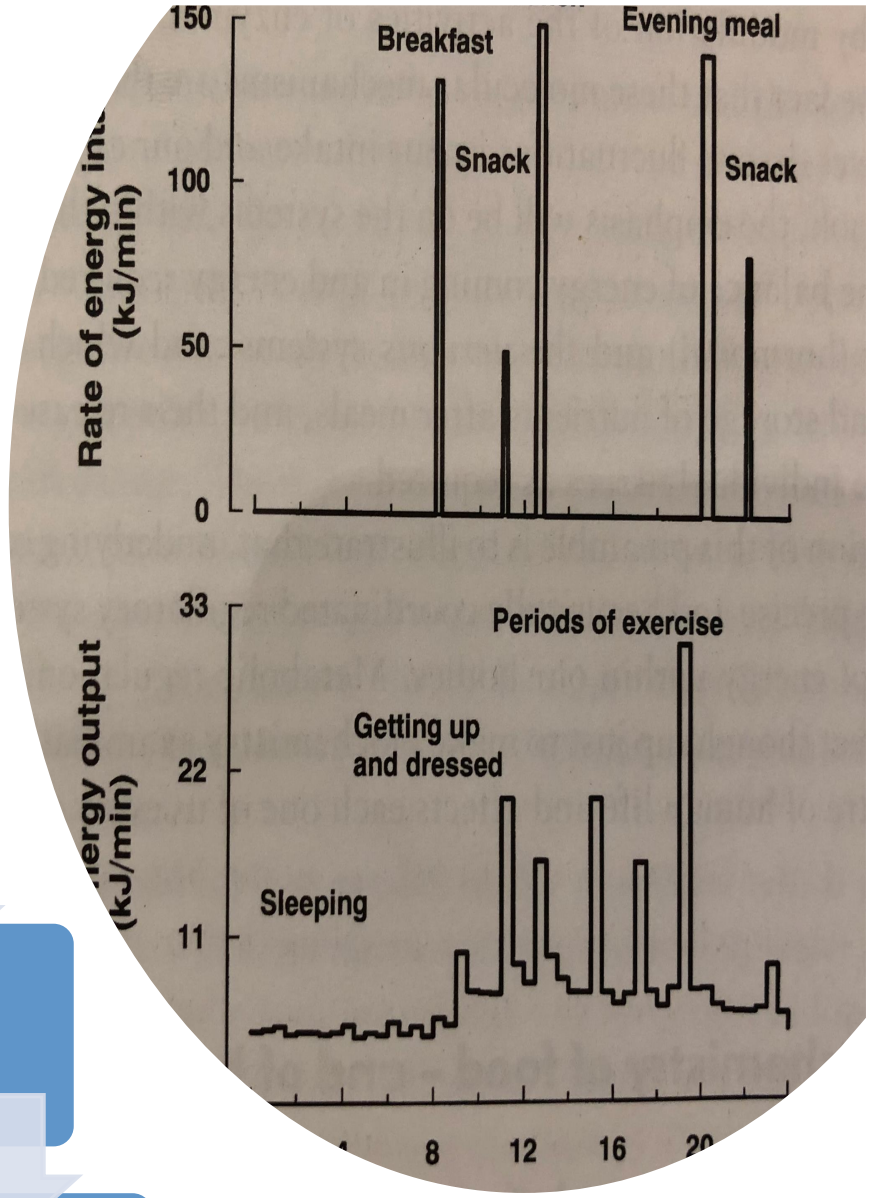
Metabolic regulation

Intake of nutrients

Delivery of energy as required

Varying from moment to moment and from tissue to tissue

In a pattern which have no relationship to the pattern of intake

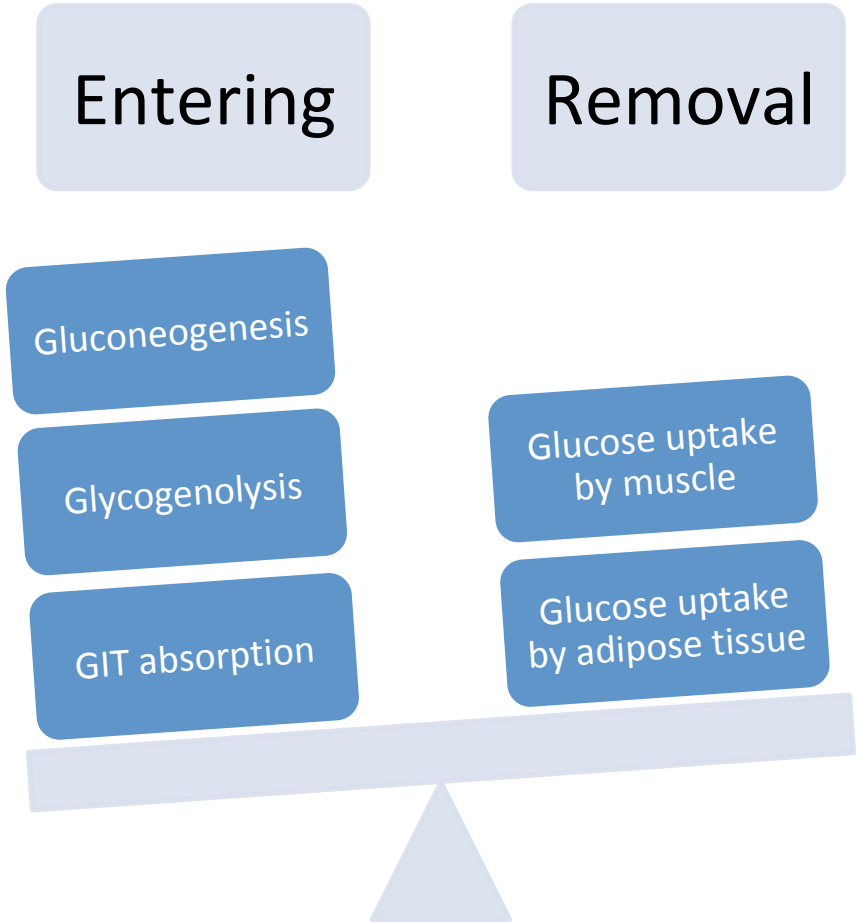


Historically diabetes was viewed as a relative or absolute Insulin deficiency.

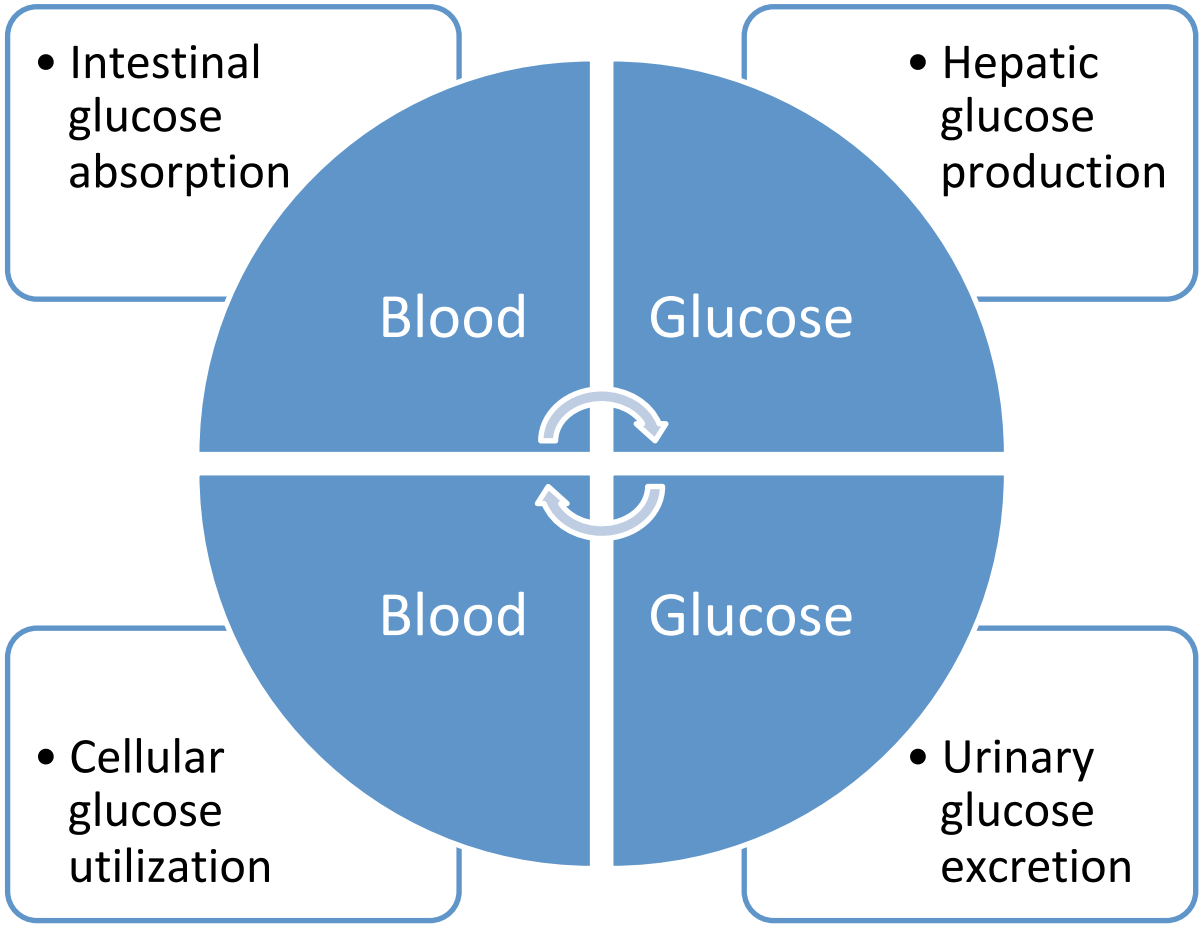
Glucoregulatory Hormones

- Insulin - pancreas β-cell
- Glucagon – pancreas α-cell
- Amylin - pancreas β-cell
- GLP-1 – L-cells of the intestine
- Other:
  - Growth hormone, Epinephrine
  - Cortisol
  - GIP – L-cells

Plasma glucose concentration is the function of the rate of glucose entering the circulation balanced by the rate of glucose removal from the circulation



Factors affecting blood glucose levels



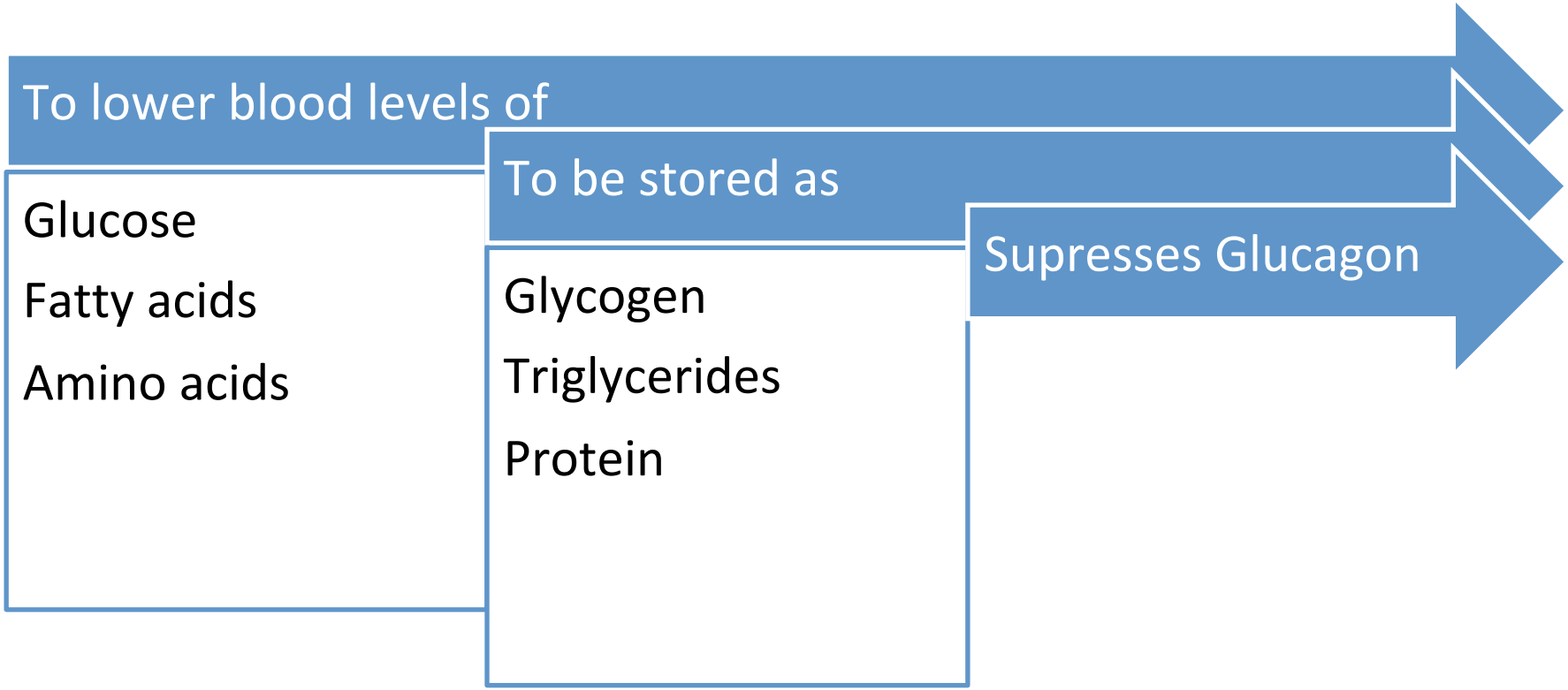
Glucose transport

Tissue that are freely permeable to glucose:

- Brain, renal medullae, RBC and WBC
- They need a constant supply for minute to minute needs

However most tissue are highly dependent upon INSULIN

Actions of Insulin



Actions of Glucagon

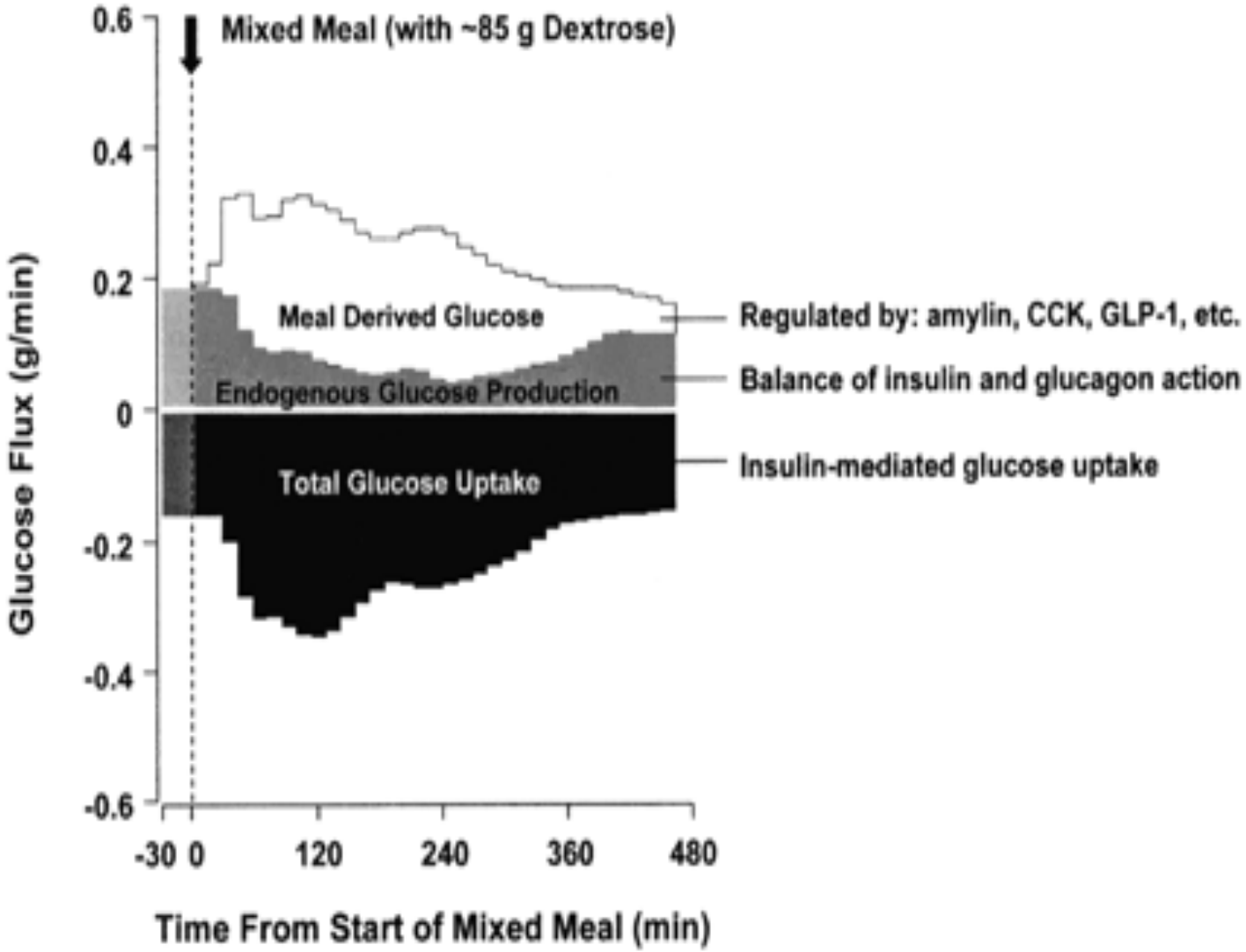
- Stimulates the breakdown of stored liver glycogen
- Promotes hepatic gluconeogenesis
- Promotes hepatic ketogenesis

Actions of Amylin

- Supresses postprandial glucagon secretion
- Slows gastric emptying
- Reduces food intake and body weight

Actions of GLP-1

- Enhances glucose-dependent insulin secretion
- Suppresses postprandial glucagon secretion
- Slows gastric emptying
- Reduces food intake and body weight


Mixed Meal (with ~85 g Dextrose)
Meal Derived Glucose
Endogenous Glucose Production
Total Glucose Uptake
Regulated by: amylin, CCK, GLP-1, etc.
Balance of insulin and glucagon action
Insulin-mediated glucose uptake
Glucose Flux (g/min)
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-30
0
120
240
360
480
Time From Start of Mixed Meal (min)

Insulin action

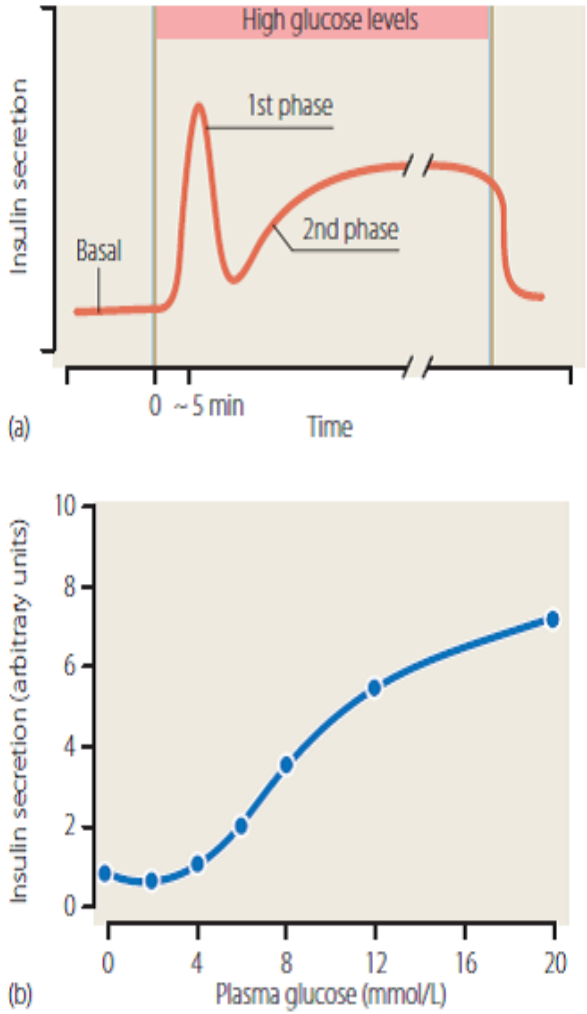
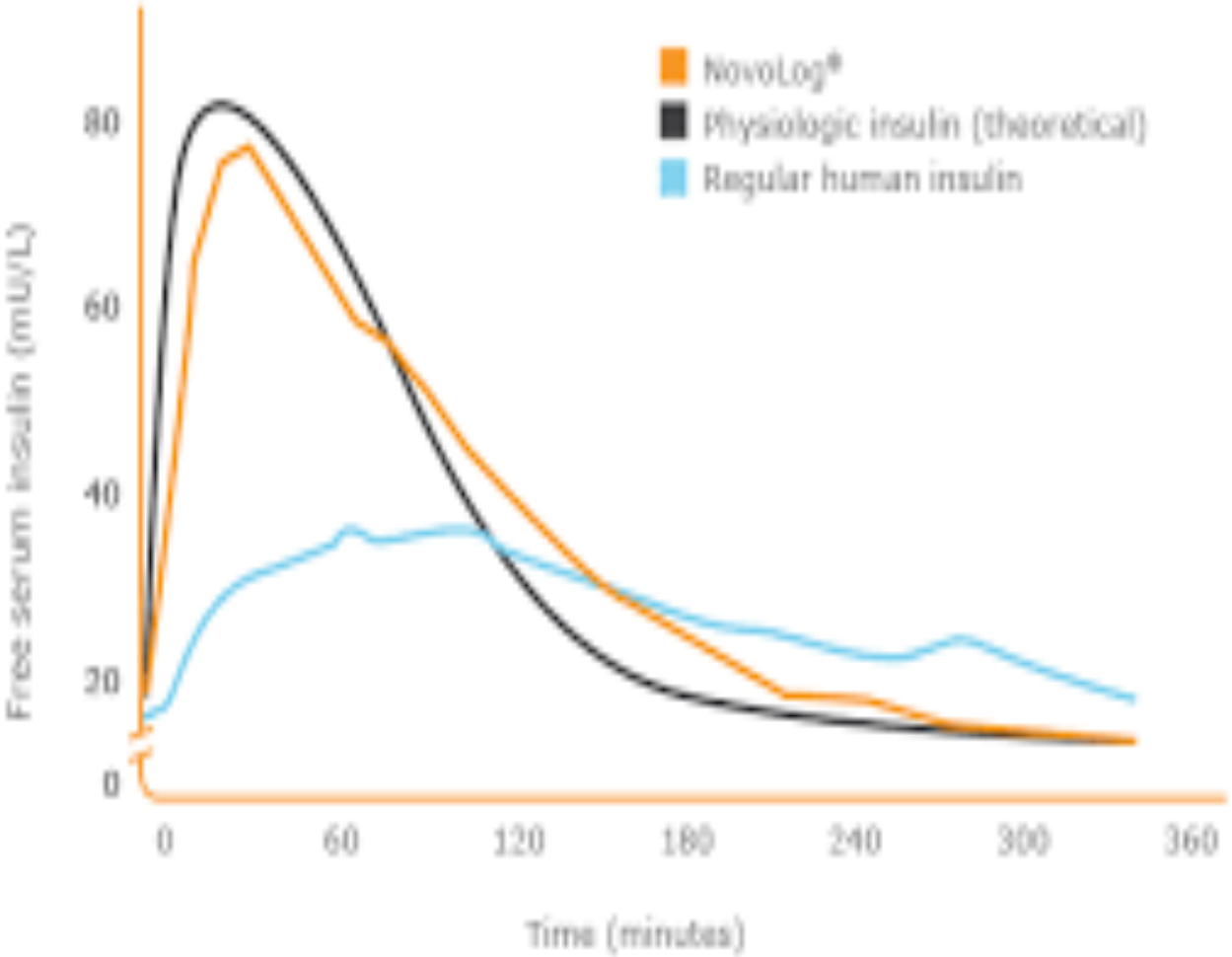


Figure 5.11 (a) The biphasic glucose-stimulated release of insulin from pancreatic islets. (b) The glucose–insulin dose–response curve for islets of Langerhans.

Insulin action



Glucose transporter proteins

GLUT-1

- Involved in basal and non-insulin-mediated glucose

GLUT-2

- Important in the islet B cell

GLUT-3

- Non-insulin uptake in the brain

GLUT-4

- Responsible for insulin-mediated glucose uptake in muscle, and adipose tissue

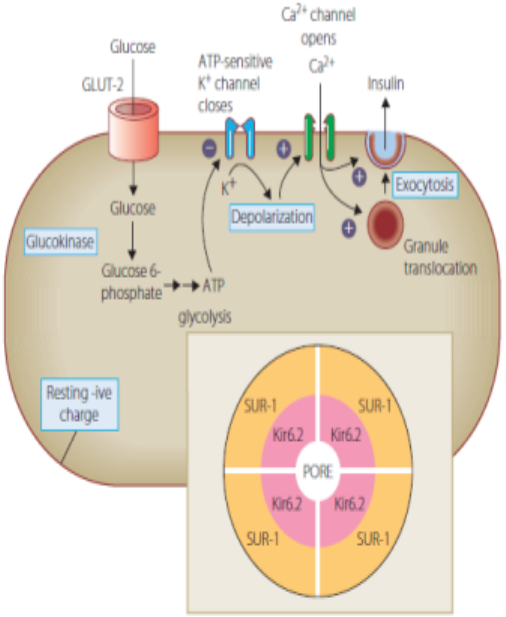


Figure 5.12 The mechanism of glucose-stimulated insulin secretion from the β cell. The structure of the KATP channel is shown in the inset.

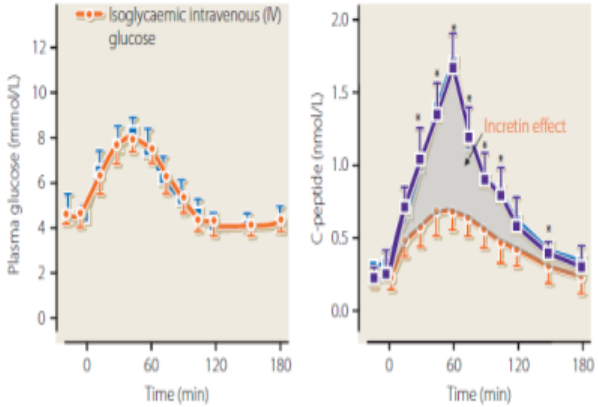
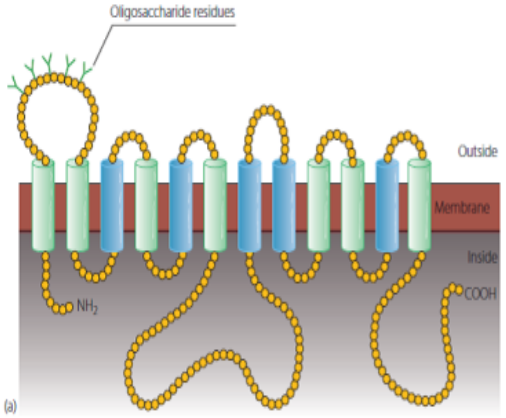


Figure 5.13 The classic experiment illustrating the incretin effect in normal subjects who were studied on two separate occasions. On one occasion, they were given an oral glucose load and on the second occasion an IV glucose bolus was administered in order to achieve identical venous plasma glucose concentration-time profiles on the two study days (left panel). The insulin secretory response (shown by C-peptide) was significantly greater after oral compared with IV glucose (right panel). Adapted from Nauck et al. J Clin Endocrinol Metab 1986; 63: 492–498.



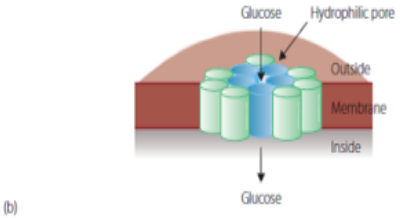


Figure 5.17 (a) The structure of a typical glucose transporter (GLUT). (b) The intramembrane domains pack together to form a central hydrophilic channel through which glucose passes.

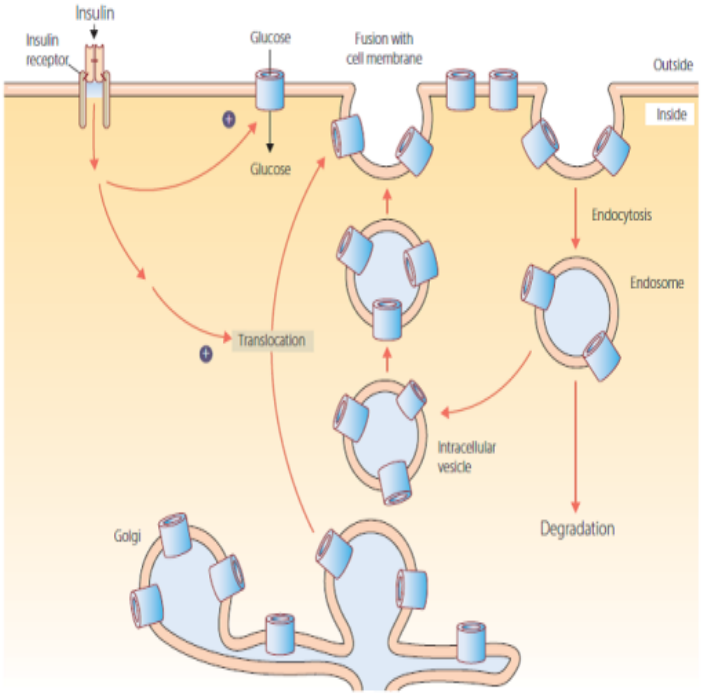
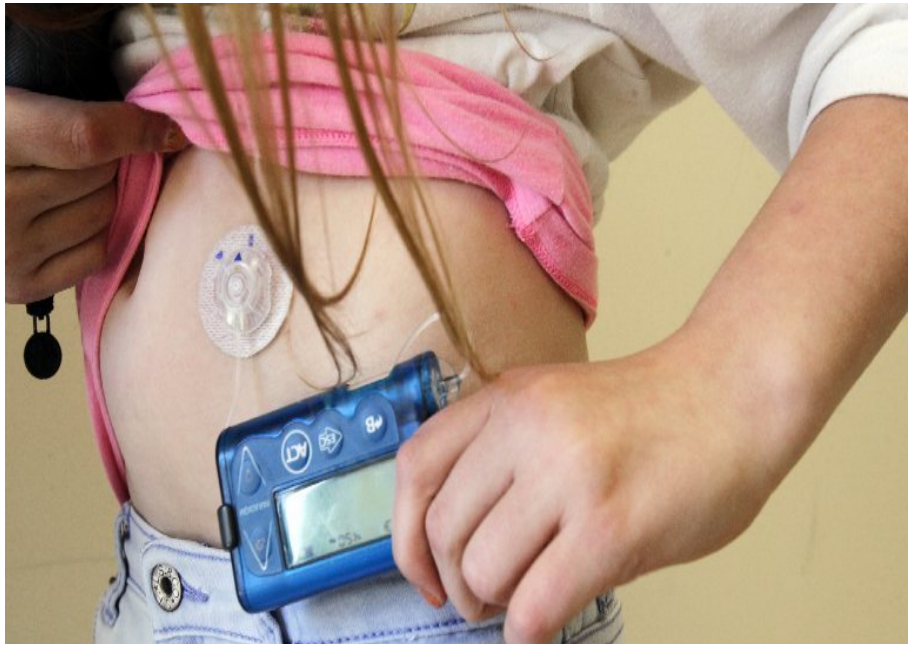


Figure 5.18 Insulin regulation of glucose transport into cells.

The Insulin Pump

- Basal
- Bolus

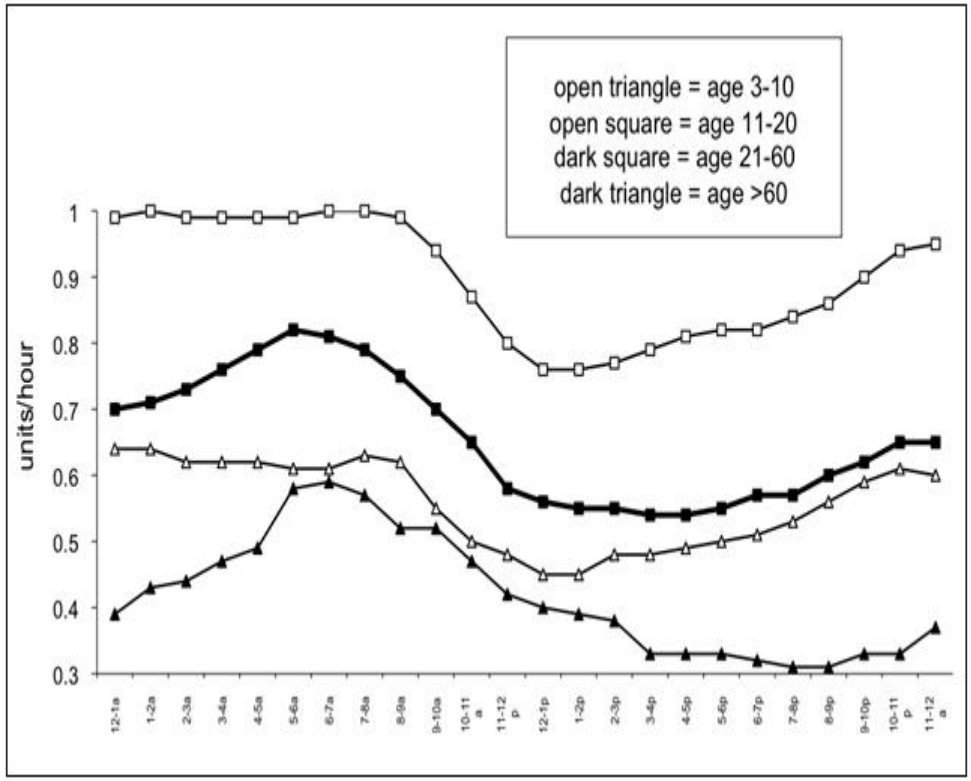


The insulin pump

BASAL INSULIN DELIVERY

- 40 -50% of total daily insulin
- Overnight basal:
  - Can you go to bed with BG 5,0-6,7 mmol and wake up with a target reading?
- Daytime basal:
  - With a target BG before a meal, can you skip that meal and have a BG rise no more than 0,85mmol or fall no more than 1,7mmol

Basal insulin requirement – age difference



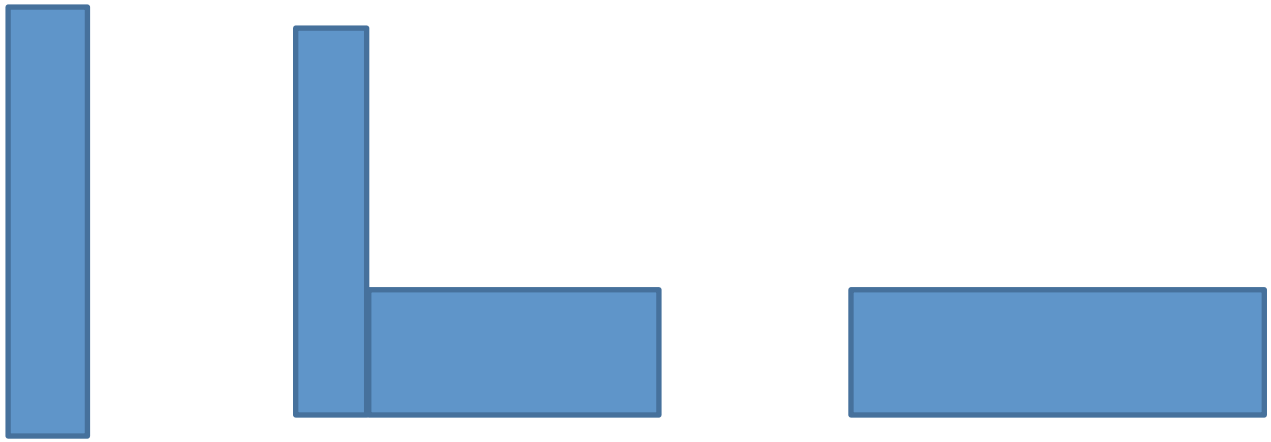
The Insulin Pump

Bolus

- Meal bolus:
  - Patient should be able to do carb counting
    - CARB RATIO: 350-450÷ Total daily dose of insulin
- Correction bolus
  - The insulin necessary to correct the BG to at least 6 mmol/L
    - Correction factor: 100÷Total daily dose of insulin

Total meal bolus: Meal bolus + Correction Bolus

CSII – Three modes to deliver insulin



Normal Dual-wave Square-wave

Insulin Pump

Complex bolus:

- Bolus necessary with high fat and high protein meal.
  - Dual wave: dose is split in % given immediately and the rest over 3 – 6 hours.

PROTEIN AND FAT MEAL CONTENT INCREASE INSULIN REQUIREMENT IN CHILDREN WITH TYPE 1 DIABETES – ROLE OF DURATION OF DIABETES

M. van der Hoogt [a], J.C. van Dyk [b], R.C. Dolman [a], M. Pieters [a]

[a] Centre of Excellence for Nutrition, North-West University, Potchefstroom, 2520, South Africa

[b] Life Groenkloof Hospital, Pretoria, 0181, South Africa

Pańkowska et al: Quantified meal insulin based on all macronutrients (carbohydrate fat and protein CFP counting.

- Increased risk for early post-prandial hypoglycemic events
- Challenging to implement in the pediatric population

ISPAD – Guide for nutritional management in children and adolescents with diabetes.

- Indicated that we need randomized controlled trials, aimed at developing methods to better manage post-prandial hyperglycaemia.

The aim of this study was to determine the post-prandial glycemic response and total insulin need for mixed meals with known, constant carbohydrate content but different fat and protein contents, using insulin pump therapy and CGM in children with type 1 diabetes

Study design

A home-based, cross-over, randomized controlled trial

- Optimal basal insulin rates, carbohydrate ratios and sensitivity factors were revised and adjusted before enrolment. (Had to remain unchanged until after data collection)
- Two meals were consumed at dinner time (18:00) under parental supervision at least a day apart and within one month.
- Participants maintained their normal habitual activity.
- Study meals could only be taken on days 2 -5 of the sensor lifespan
- All participants used rapid acting insulin Novorapid.

Test meals

The macronutrient content was calculated as follows:

- Total daily energy requirement for each participant was individually calculated using age, weight and gender specific WHO energy expenditure recommendation.
- Total carbohydrate per day was calculated at 50% of total energy, since 50 -55% is recommended for children with type 1 diabetes. -ISPAD
- Of the total daily carbohydrates, 25% was allocated to each meal.

Test meals

The macronutrient content was calculated as follows:

- The amount of carbohydrates for both meals was kept constant in order for the LFLP meal to be used as the control for the HFHP meal.
- The fat and protein content per meal, calculated as percentage energy, were as follows:

LFLP	Carbohydrate 60%	FAT 25%	PROTEIN 15%
HFHP	CARBOHYDRATE 40%	FAT 35%	PROTEIN 25%

Outcome measures Medtronic Carelink Software professional version.

Peak sensor glucose value post meal

- Maximum post meal glucose excursion above 6 mmol/L

Time to peak sensor glucose excursion

- Time it took following consumption of meal, to reach the maximum post-meal glucose excursion.

Time of first and largest correction bolus

Total correction bolus

- Total additional insulin

Total amount of insulin needed for the meal

- Meal bolus and correction bolus

Additional insulin required – correction bolus as percentage of total bolus

Outcome measures Medtronic Carelink Software professional version.

Area under the response curve (AUC)(≥ 8 mmol/L) post meal calculated using the trapezoidal method

Duration of elevated post-prandial glucose

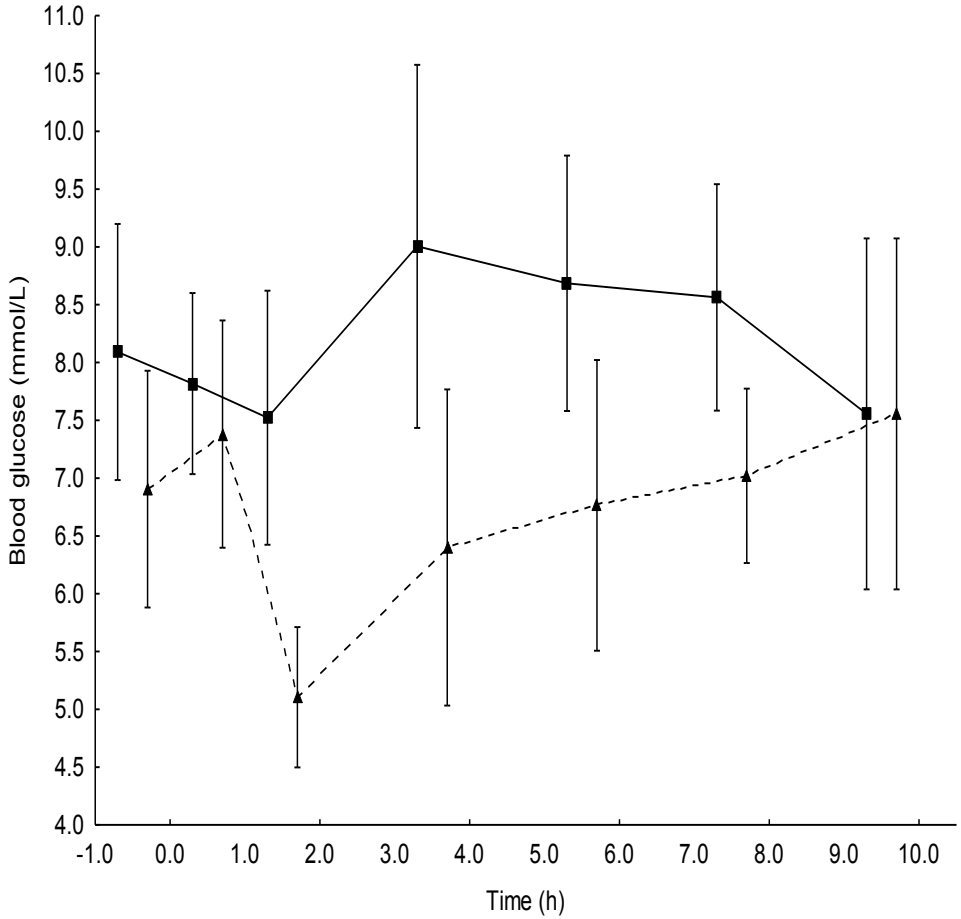
- Total time of elevated post-prandial glucose spent above 6 mmol/L

Table 2: Insulin dosage and sensor glucose response curve comparisons between test meals

[a] food bolus and correction boluses; [b] correction bolus expressed as % of initial food bolus;
[c] (difference between peak sensor glucose value and target of 6 mmol/L); AUC – area under the sensor glucose curve,
[d] total time of elevated post-prandial glucose spent above 6 mmol/L. Data reported as mean ± SD or median (25th ; 75th percentile) depending on normality

Dependent variable	LFLP	HFHP	P
Total correction insulin (units)	0.15 (0 ; 0.53)	1.2 (0.48 ; 2.32)	<0.0001
Total meal insulin (units) [a]	2.70 (1.68 ; 5.80)	3.48 (2.43 ; 7.81)	<0.0001
Additional insulin required (%) [b]	11.3 ± 5.36	31.1 ± 16.3	<0.0001
Time of 1st correction bolus (min post-meal)	352 ± 204	352 ± 170	0.81
Time of largest correction bolus (min post-meal)	399 ± 192	420 ± 160	0.7
Basal suspend duration (min)	86.1 ± 79.9	53.3 ± 53.9	0.052
Duration of elevated post-prandial glucose (min) [d]	185 ± 124	364 ± 142	<0.0001
Peak sensor glucose value post-meal (mmol/L)	9.22 ± 2.09	10.3 ± 2.77	0.14
Time to peak sensor glucose value (min post-meal)	233 ± 204	342 ± 178	0.056
Sensor glucose peak excursion [c]	3.42 ± 1.94	4.29 ± 2.77	0.18
AUC (above 8 mmol/L)	46.3 (0 ; 211)	198 (11.7 ; 505)	0.02
Occurrence of hypoglycaemic events n (%)	7 (32)	1 (0.05)	0.02

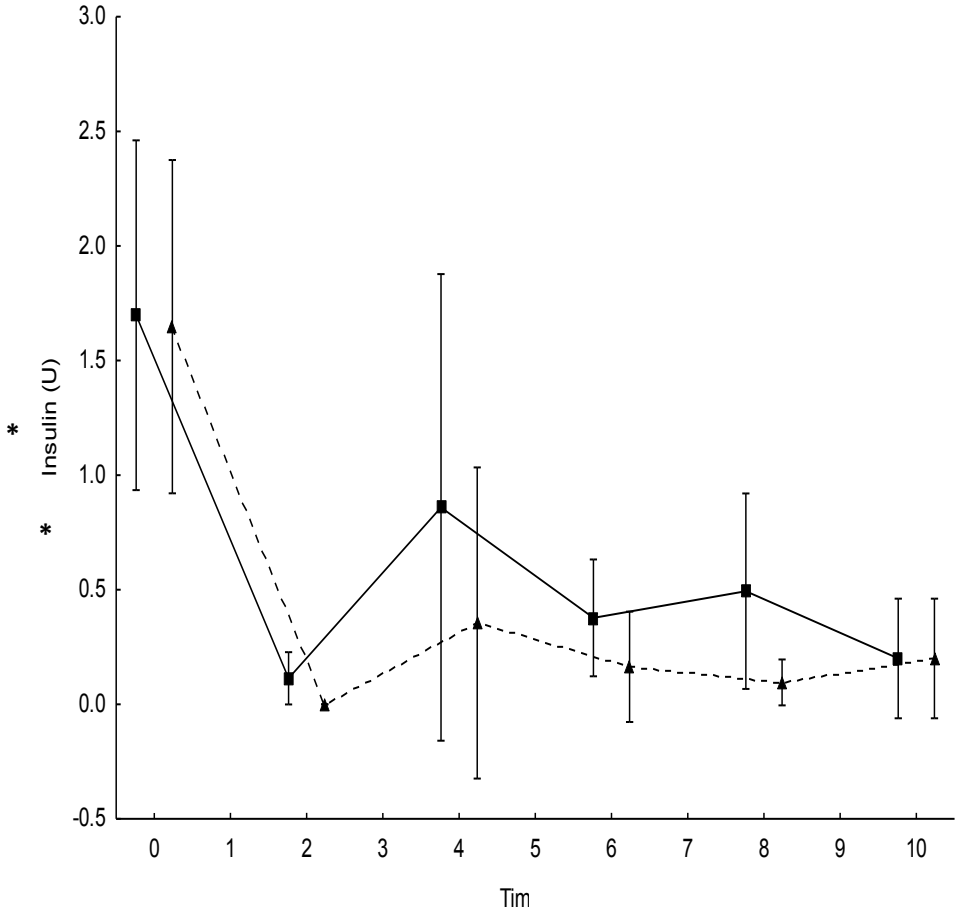
Figure 1 Blood glucose levels before (Time 0h) and after (Time 0.5 – 10h) intervention



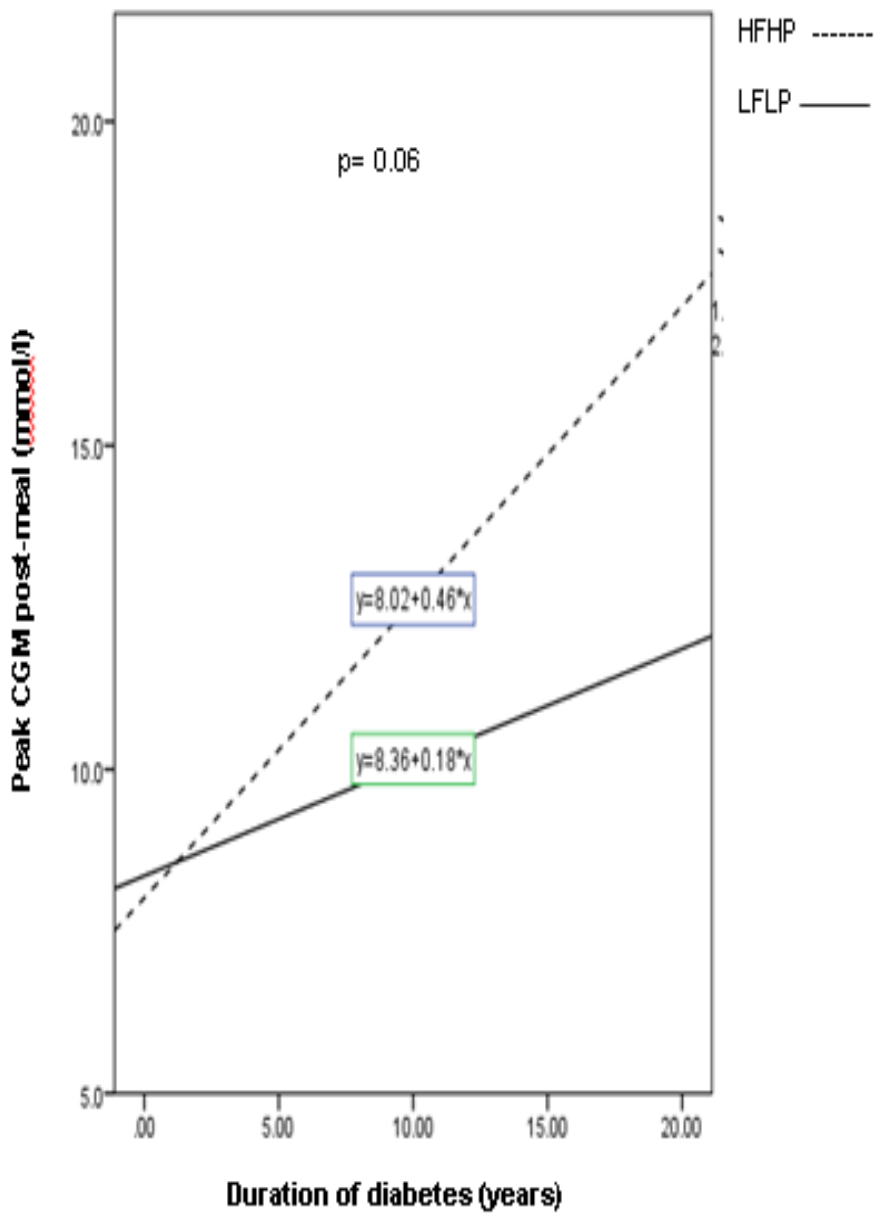
■ – High fat, high protein meal; ▲- Low fat, low protein meal

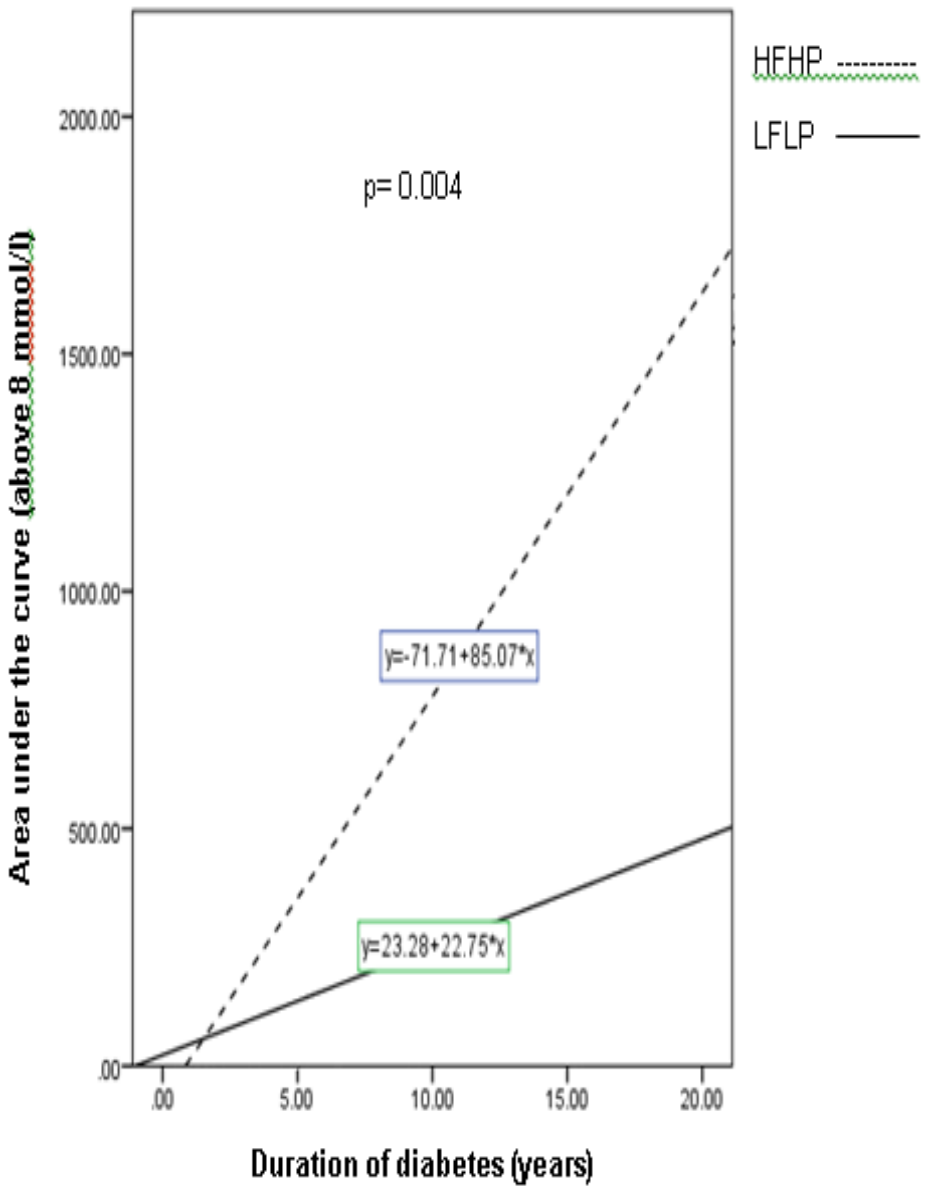
* - significant difference between the two meals ($p < 0.05$) at the respective time points

Meal bolus (T 0h) and correction insulin (T 2 - 10h)



- ■ – High fat, high protein meal; ▲- Low fat, low protein meal
- * - significant difference between the two meals ($p < 0.05$)


HFHP
LFLP
p= 0.06
y=8.02+0.46*x
y=8.36+0.18*x
Peak CGM post-meal (mmol/l)
20.0
15.0
10.0
5.0
.00
5.00
10.00
15.00
20.00
Duration of diabetes (years)


HFHP
LFLP
p= 0.004
y=-71.71+85.07*x
y=23.28+22.75*x
Area under the curve (above 8 mmol/l)
2000.00
1500.00
1000.00
500.00
.00
.00
5.00
10.00
15.00
20.00
Duration of diabetes (years)

This study highlight the additional insulin needed for a typical mixed meals in children with type 1 diabetes and shows that all macronutrients require insulin.

With the addition of each 1 gram of fat requiring double the amount of correction insulin compared to each gram of protein

For the first time, duration of diabetes(regardless of age) is shown to be strongly associated with post-prandial hyperglycemia

Insulin Pump

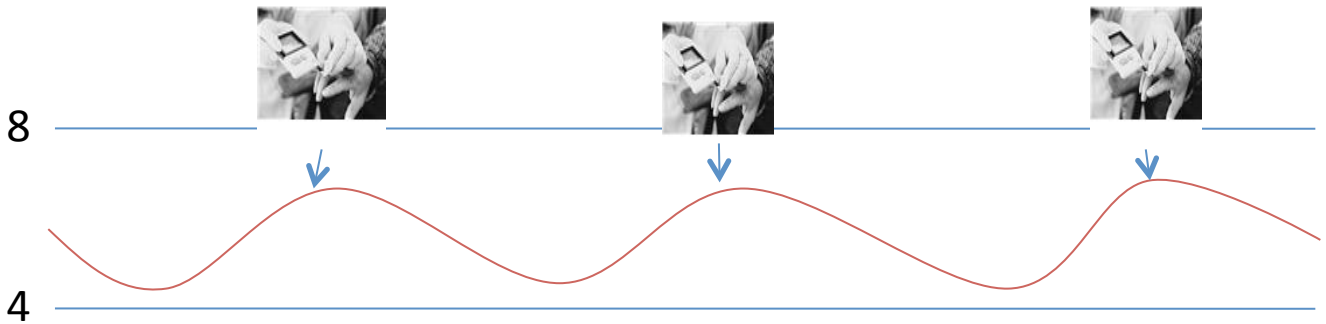
Trouble shooting:

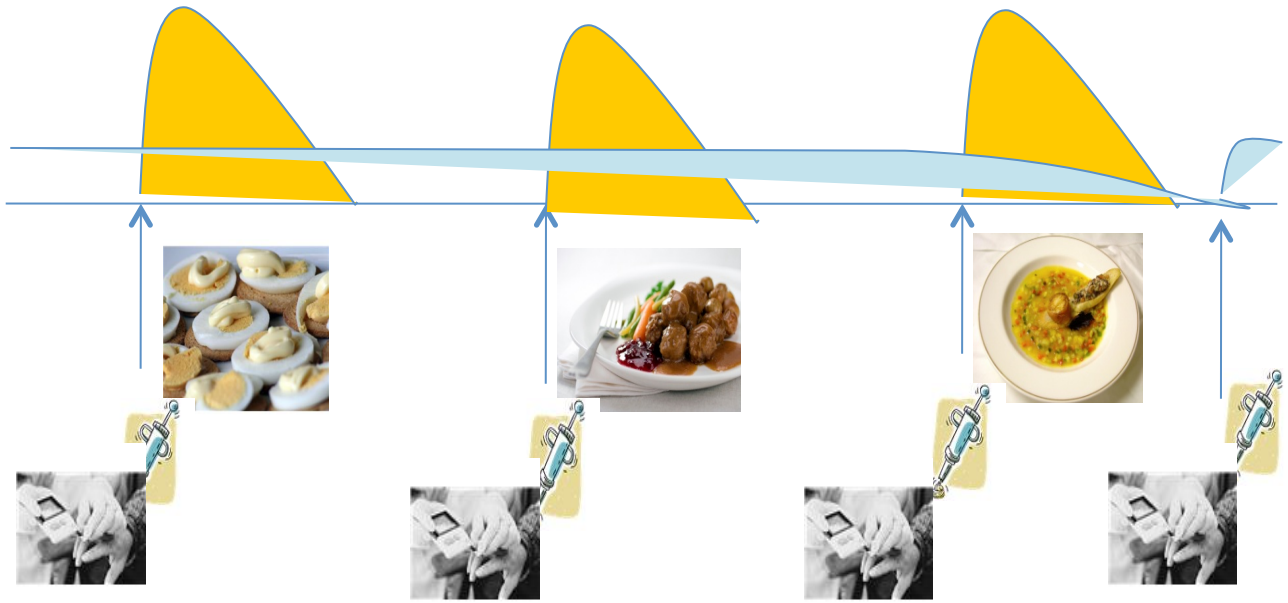
- Exercise
- Low Blood Glucose
- High Blood Glucose

Insulin Pump

Other setting:

- Active insulin time
- Bolus increment
- Basal increment
- Maximum bolus
- Maximum basal
- Temp basal type


8
4



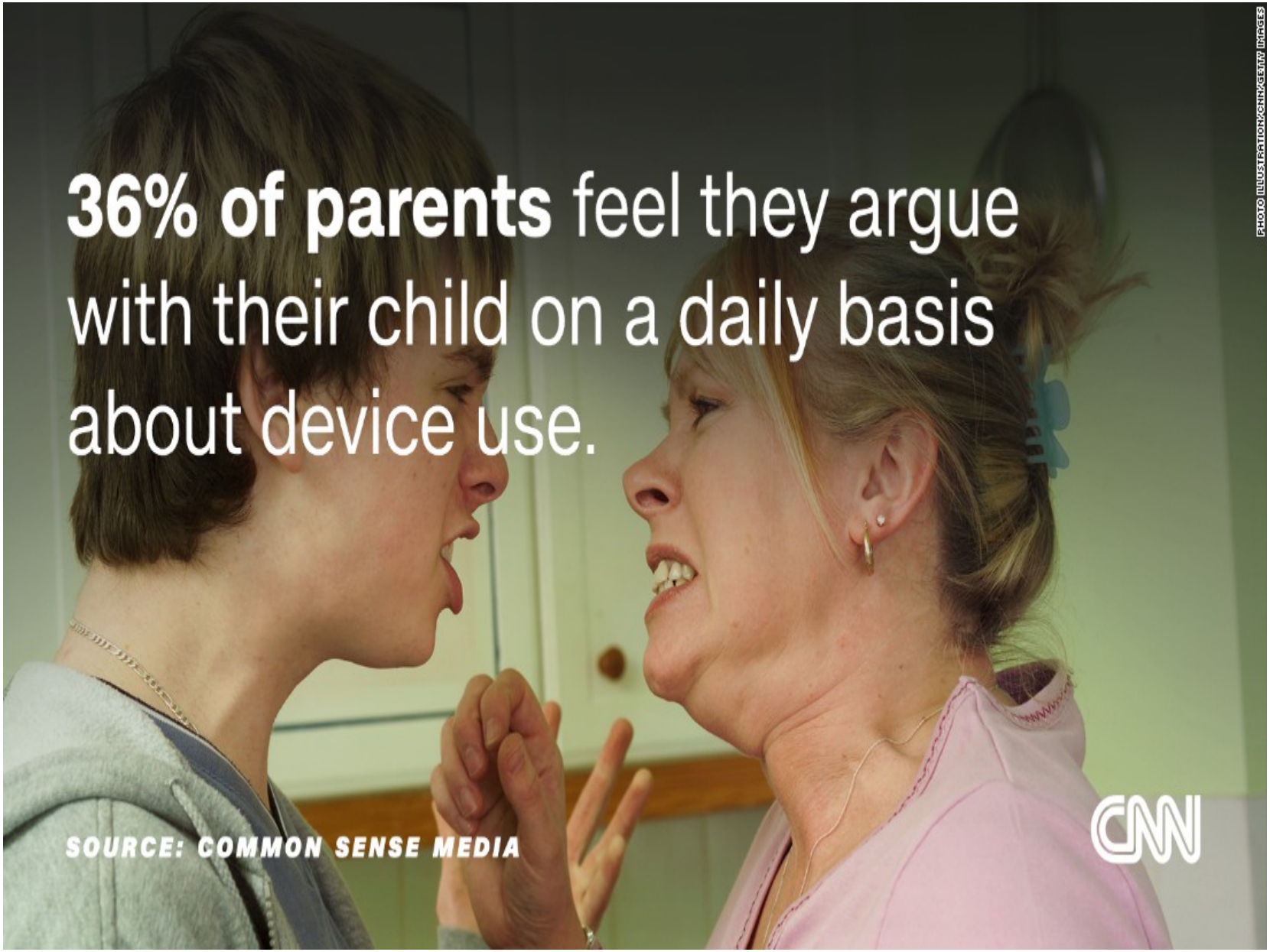
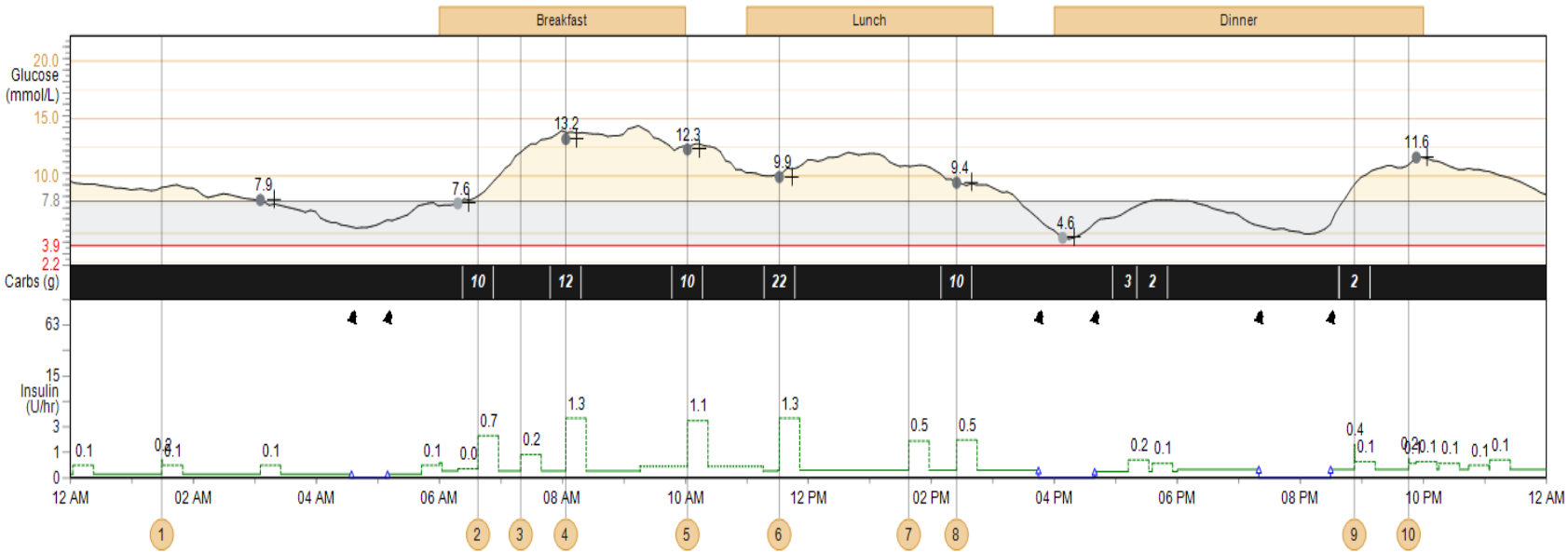


PHOTO ILLUSTRATION/CNN/GETTY IMAGES

Insulin Pump

Sensor Augmented insulin Pump therapy

- Major advancement is the predicted low glucose suspend



Bolus Events										
Bolus Event	1	2	3	4	5	6	7	8	9	10
Time	01:29 AM	06:37 AM	07:19 AM	08:03 AM	10:02 AM	11:31 AM	01:37 PM	02:24 PM	08:52 PM	09:45 PM
Bolus Type	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Delivered Bolus Norm (U)	0.175	0.650	0.225	1.28	1.13	1.28	0.500	0.525	0.400	0.150
+ Square Portion (U, h:mm)	--	--	--	--	--	--	--	--	--	--
Recommended Bolus (U)	--	0.650	--	1.28	1.13	1.28	--	0.525	0.400	--
Difference (U)	--	--	--	--	--	--	--	--	--	--
Carbs (g)	--	*10*	--	*12*	*10*	*22*	--	*10*	*8*	--
Carb Ratio Setting (g/U)	--	15.0	--	15.0	20.0	20.0	--	20.0	20.0	--
Food Bolus (U)	--	0.650	--	0.800	0.500	1.10	--	0.500	0.400	--
BG (mmol/L)	--	--	--	**13.2**	**12.3**	**9.9**	--	**9.4**	--	--
BG Target Setting (mmol/L)	--	5.5 - 6.5	--	5.5 - 6.5	5.5 - 6.5	5.5 - 6.5	--	5.5 - 6.5	5.5 - 6.5	--

Statistics	09/28		09/26 - 10/09	
Avg BG (mmol/L)	**9.6**		**9.4 ± 3.4**	
BG Readings	8		119	8.5/day
Readings Above Target	6	75%	75	63%
Readings Below Target	--	0%	3	3%
Sensor Avg (mmol/L)	**9.1 ± 2.5**		**9.3 ± 2.6**	
Avg AUC > 7.8 (mmol/L)	1.82	1d 0h	1.96	13d 13h
Avg AUC < 3.9 (mmol/L)	0.00	1d 0h	0.00	13d 13h

Daily Carbs (g)	*79*	*90 ± 19*
Carbs/Bolus Insulin (g/U)	10.5	10.4

Total Daily Insulin (U)	11.85	13.03 ± 1.7

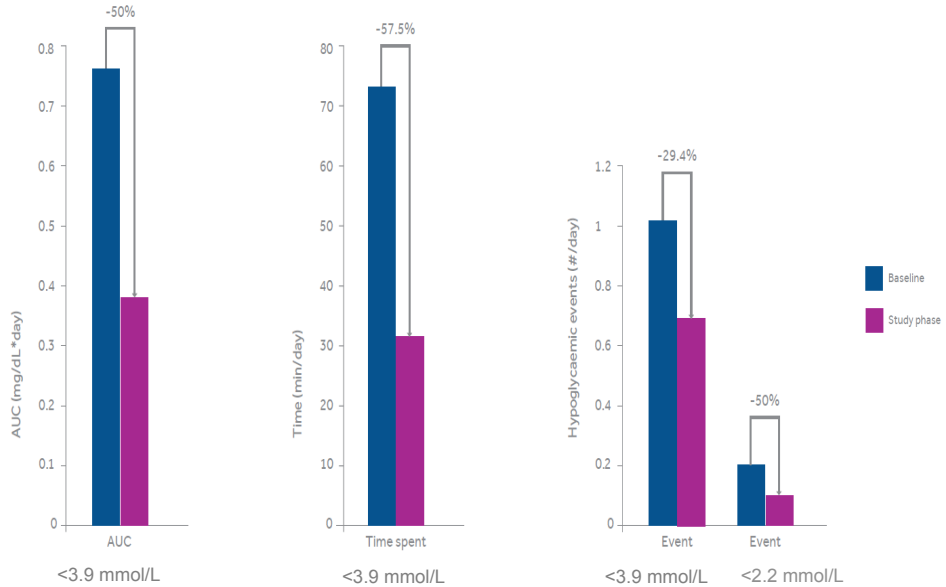
MINIMED™ 640G WITH SMARTGUARD™ TECHNOLOGY HYPOGLYCAEMIA REDUCTION IN PAEDIATRICS

OBJECTIVES To evaluate the effectiveness of SmartGuard suspend before low feature in reducing hypoglycaemia, compared to conventional SAP therapy, in a paediatric population

RESULTS

Reduction in Hypoglycaemia:

Area Under the Curve | Time spent | Number of events



- Best results, with no hyperglycaemic rebound, when no intervention with SmartGuard.
- 76.8% avoidance of low limit following SmartGuard suspension events

INSIGHT SmartGuard significantly reduces hypoglycaemia in paediatrics, for optimal result patients should be educated to trust the technology and 'let SmartGuard do the work'.

DESIGN

- Before/After
- Study
- SmartGuard ON
- vs OFF 8 weeks
- 24 subjects
- Type 1
  Aged 3-17

REFERENCE

Biester T. et al. "Let the Algorithm Do the Work": Reduction of Hypoglycemia Using Sensor- Augmented Pump Therapy with Predictive Insulin Suspension (SmartGuard) in Pediatric Type 1 Diabetes Patients. Diabetes Technol Ther. 2017; 19(3):173-182

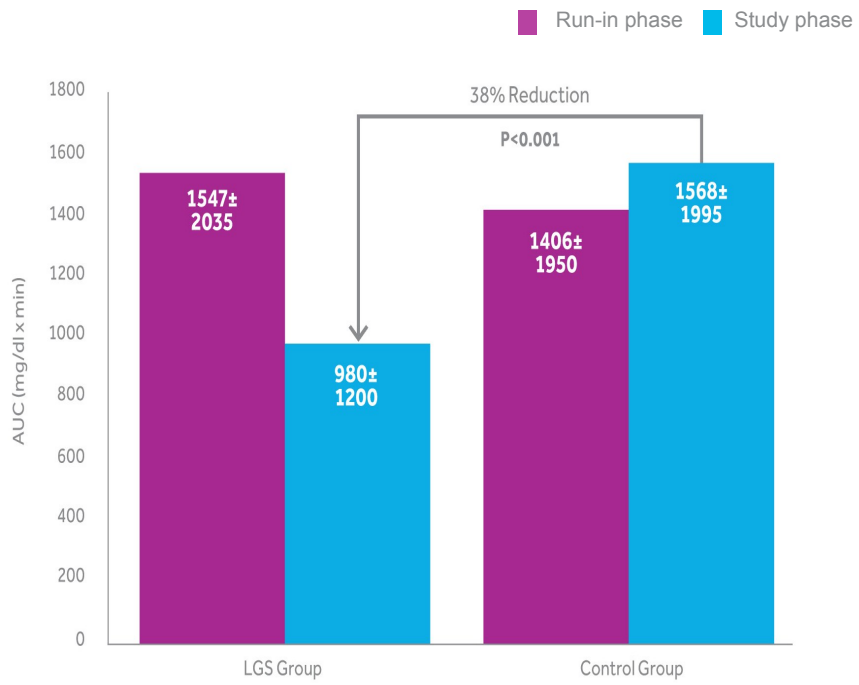
Medtronic
Further, Together

ASPIRE IN-HOME

BENEFIT OF SAP WITH LGS COMPARED TO STANDARD SAP

OBJECTIVES The study aimed to evaluate the clinical effectiveness of SAP therapy with the LGS feature, as compared to SAP without LGS feature, on nocturnal hypoglycaemia and HbA1c leve!'s in patients with documented nocturnal hypoglycaemia.

RESULTS The mean AUC for nocturnal hypoglycaemic events was 38% lower in the LGS Group than in the Control Group



INSIGHT Low Glucose Suspend can reduce by 38% the mean AUC of nocturnal hypoglycemia without increasing HbA1c vs SAP

THE CLOSE FUTURE

New insulin

Fast-acting Insulin Aspart

- By adding L-arginine and niacinamide
  - L-arginine – stabilising agent
  - Niacinamide – accelerated initial absorption

Studies published in adults - paediatric studies ongoing

GLP-1

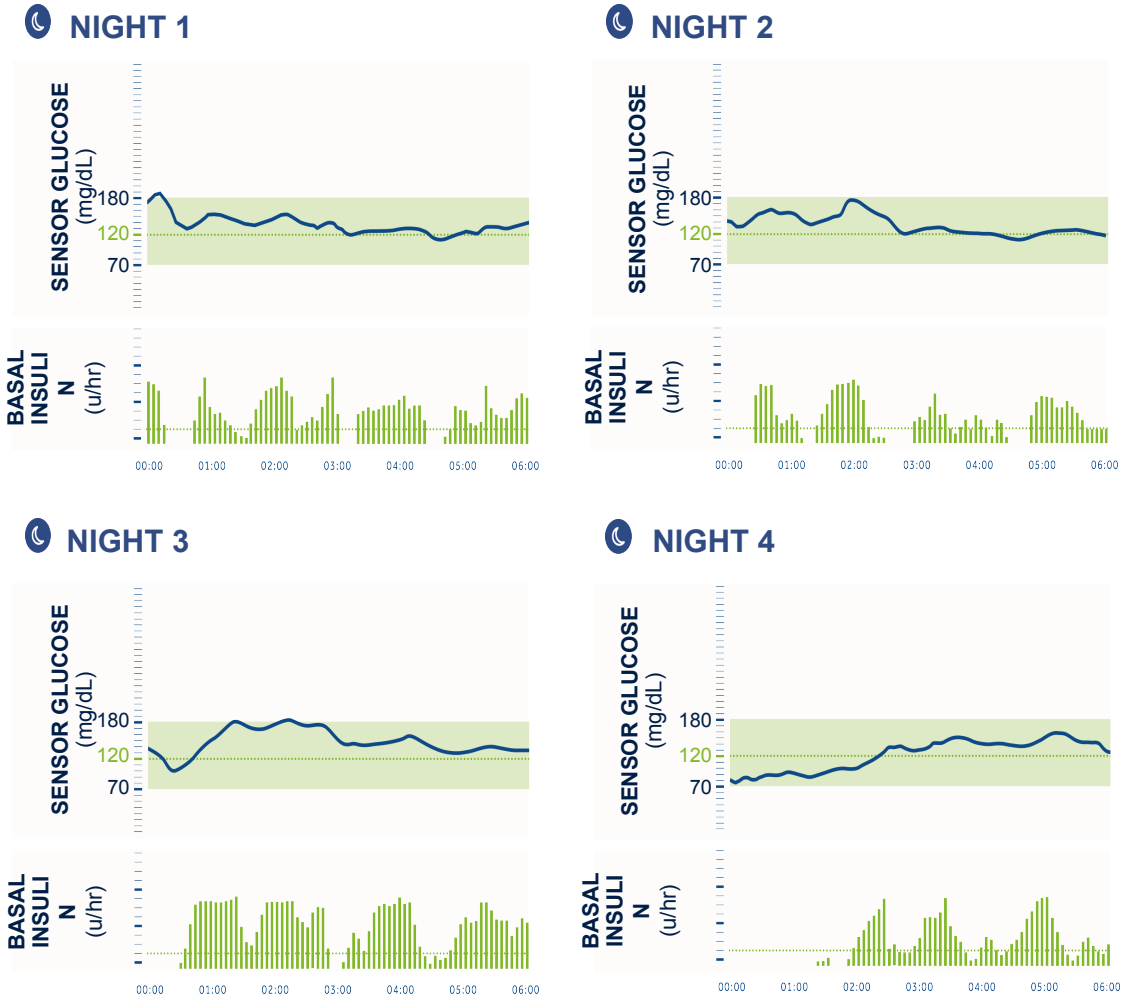
? Use in type 1 diabetes

MINIMED™ 670G SYSTEM WITH SMARTGUARD™ TECHNOLOGY

COMPARING GLUCOSE REQUIREMENTS OVER 4 DIFFERENT NIGHTS

EACH DAY AND NIGHT, INSULIN NEEDS VARY

By constantly adapting to real-time insulin needs, SmartGuard™ technology may deliver very different basal rates each day and night – helping patients stay in a healthy glucose range.[1,2]



1) Bergenstal, R. M. et al. Jama. 2016; 316 (13): 1407 – 1408

2) Garg SK et al. Diabetes Technol Ther. 2017 Mar;19(3):155-163