Functional insulin therapy: relationship to carbohydrate intake

Prof. Andrej Janež MD, PhD

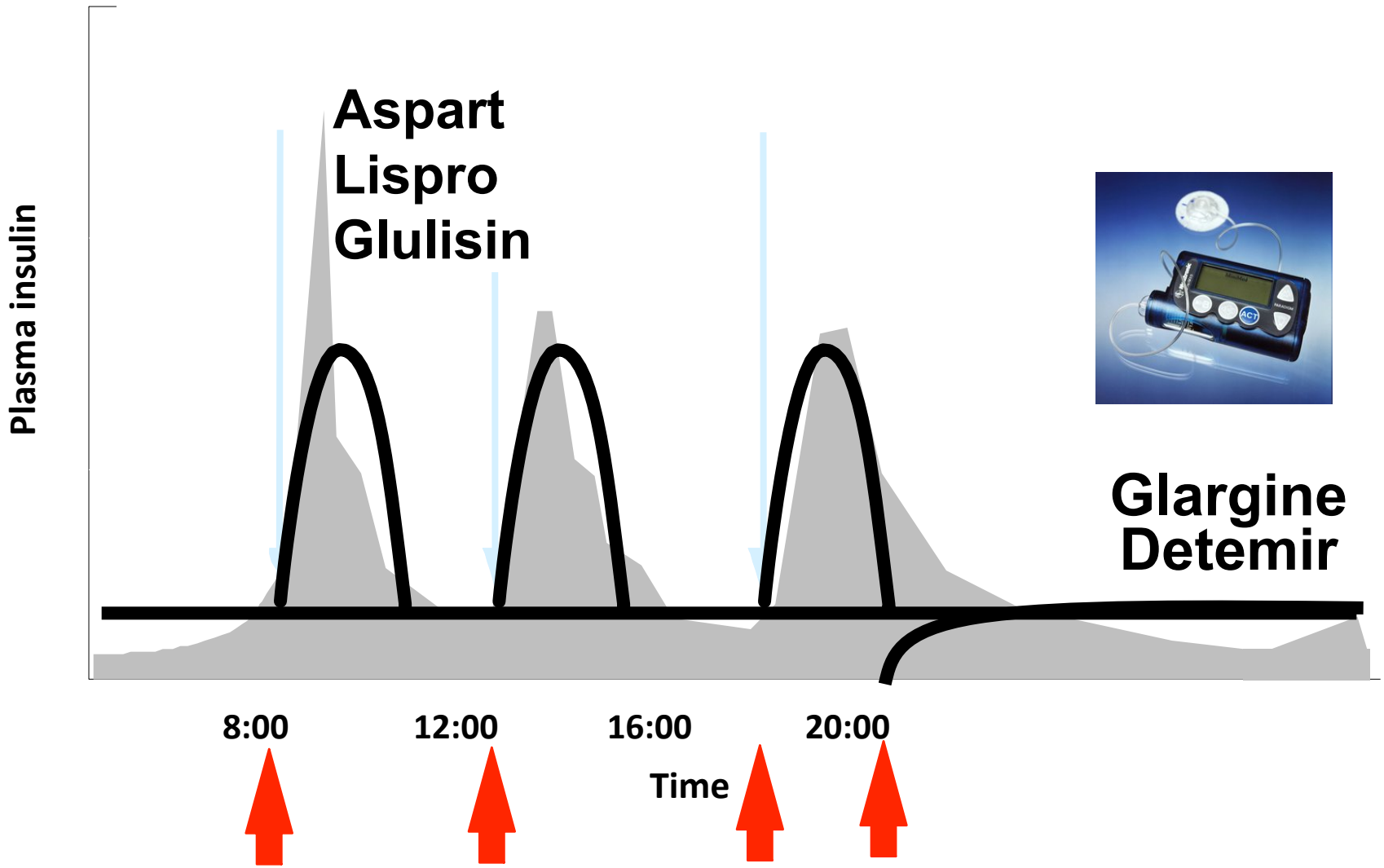
University Medical Centre Ljubljana, Slovenia

univerzitetni
klinični center ljubljana

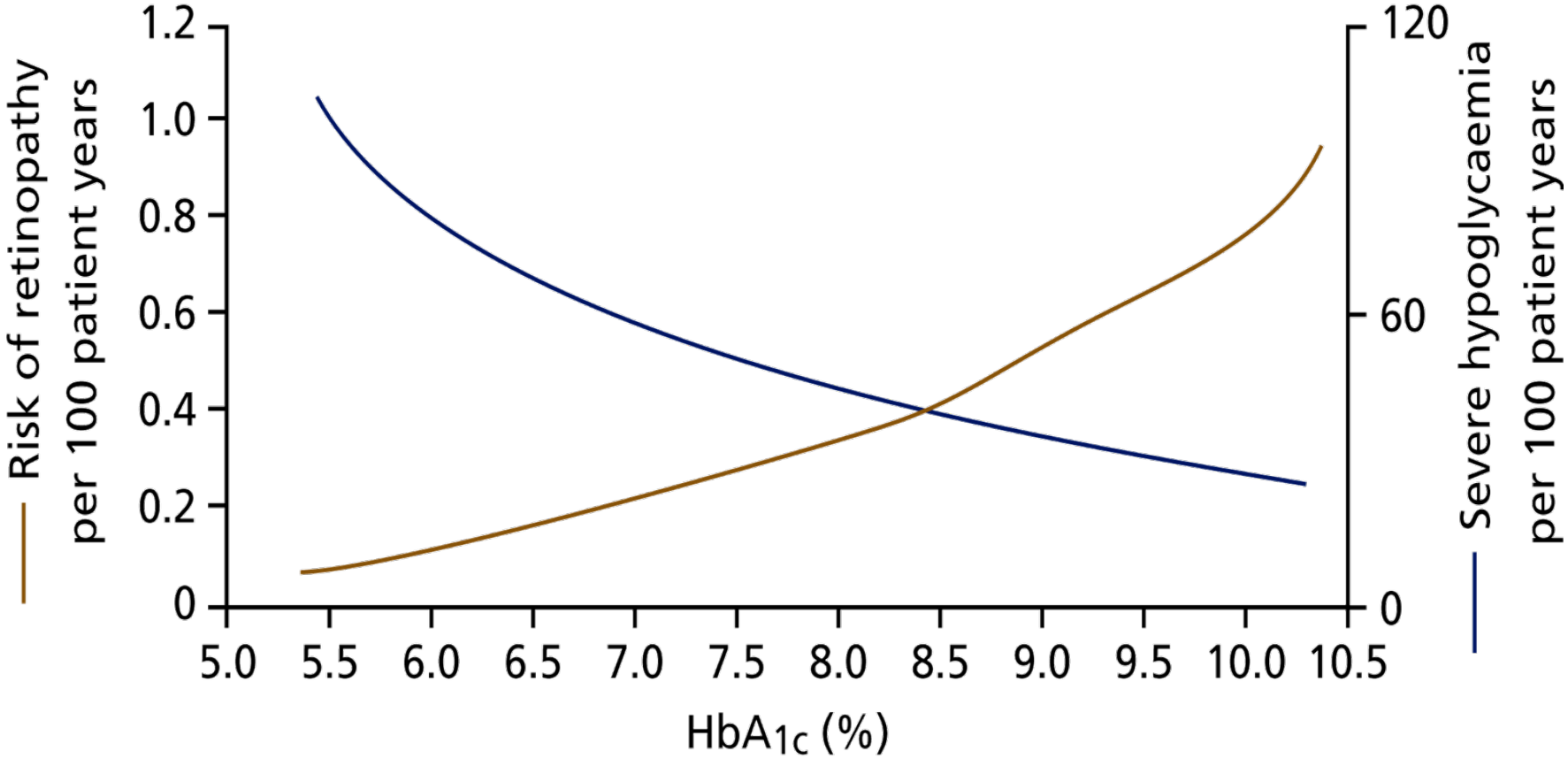
Conflict of interests

Merck Sharp&Dohme, Novo Nordisk, Novartis, Boehringer Ingelheim, Sanofi, Takeda,Lilly, Astra Zeneca, Lifescan, Medtronic

Basal/Bolus insulin treatment with rapid-acting and long-acting analogs or pumps

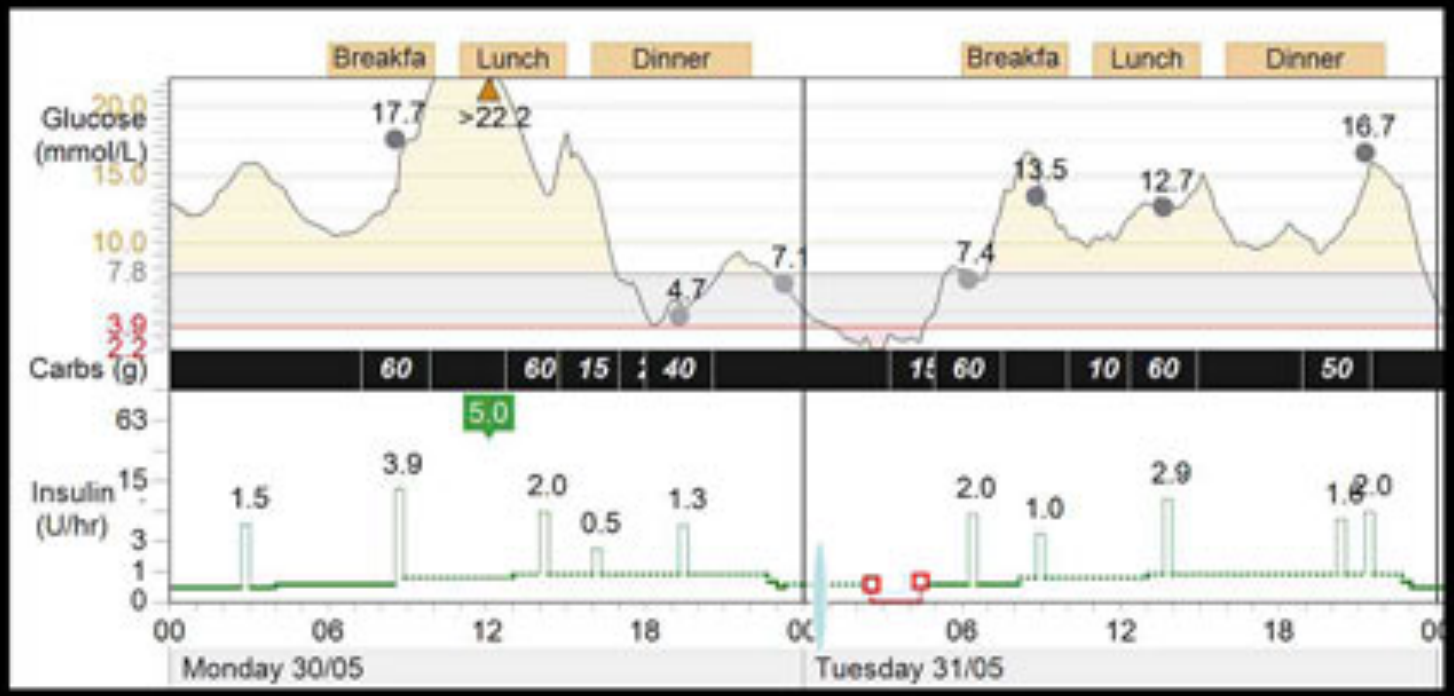


DCCT study



DCCT Research Group. New Engl J Med 1993;328:977.

Postprandial hyperglycaemia is a major source of blood glucose variability



Computer download from CSII patient

Goals of Functional insulin therapy (FIT)

- **normoglycemia (HbA1c < 6,5%)**
- **no hypos**
- **flexible eating (dietary freedom)**

FIT knowledge

1. Functional insulin replacement

All about insulins

Comprehension: basal bolus, prandial, correction bolus

Insulin dose adjustment

2. Tests of basal insulin, Carb factor, correction factor

3. Functional insulin replacement

under special conditions (exercise, illness…)

Carbohydrate Counting and Diabetes

Why Carb Count?

- Need some methodology on which to base rapid-acting insulin dosing with meals/snacks
- Can allow for more flexibility with eating for people with type 1 diabetes
- Theoretically, should better match insulin bolus to carb intake and result in reduced post-prandial hyper- and hypoglycemia

Benefits of Adjusting Insulin for Carbohydrates

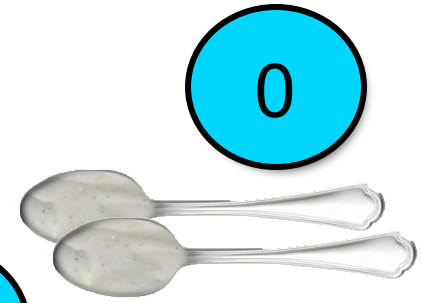
- Allows More Flexibility
  - No need to stay within carb ranges for meals
  - For patients on pump therapy or MDI eating schedule can be much more flexible
- More Advanced Form of Diabetes Management
- Potential for more accurate dosing
- Pump therapy requires carb input

Estimating CHO

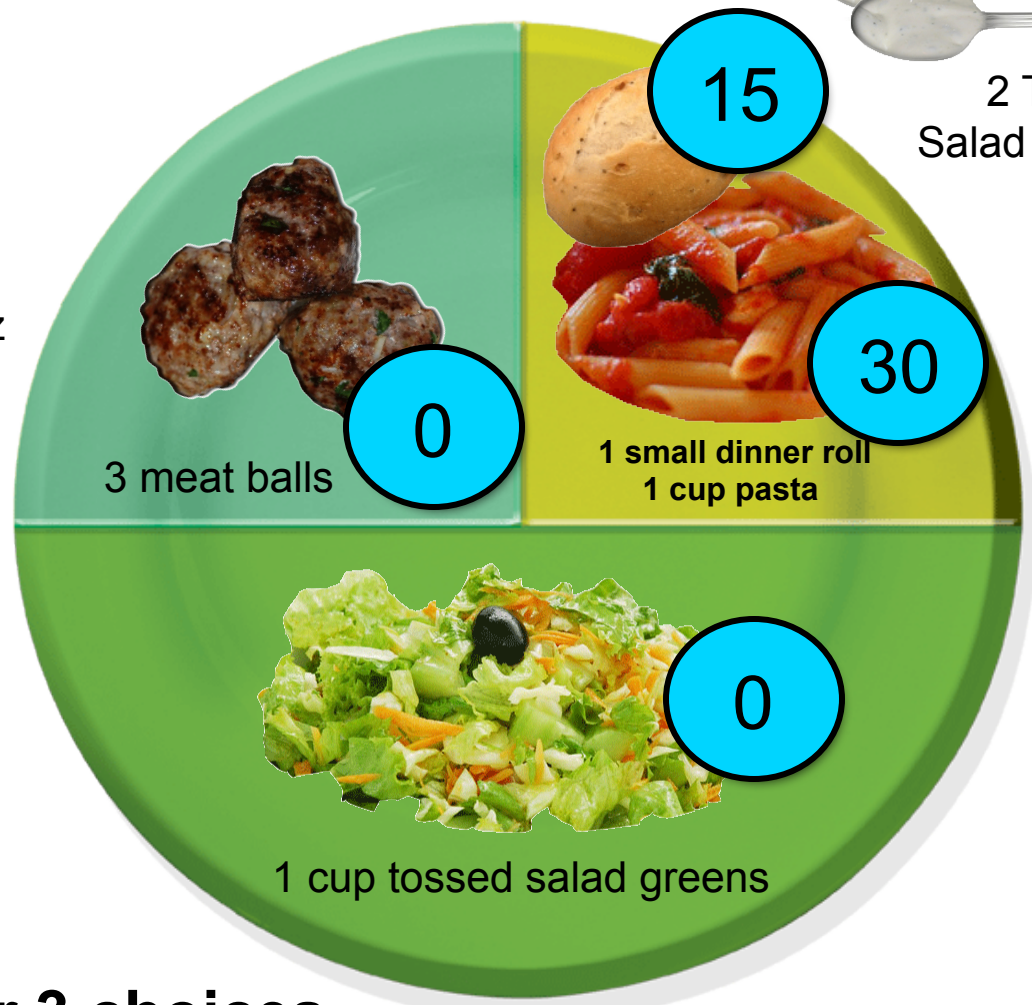
- Weighing food
- Measuring using cups & spoons
- Food labels
- Recipes that list CHO content
- CHO Counting tables/books

How many Carbs?

Wine* - 5 oz



2 Tbsp.
Salad dressing



Wine	0 grams
Meat balls	0 grams
Pasta w/ tomato sauce	30 grams
Dinner roll	15 grams
Salad greens	0 grams
Salad dressing	+ 0 grams

TOTAL = 45 grams or 3 choices

* According to the ADA, "If adults with diabetes choose to use alcohol, daily intake should be one drink per day or less for adult women and two drinks per day or less for adult men".

Food Labels

Nutrition Facts

Serving Size ½ cup (114g)
Servings Per Container 4

Amount Per Serving

Calories 90	Calories from Fat 30
	% Daily Value*
Total Fat 3g	**5%**
Saturated Fat 0g	**0%**
Cholesterol 0mg	**0%**
Sodium 300mg	**13%**
Total Carbohydrate 13g	**4%**
Dietary Fiber 3g	**12%**
Sugars 3g	
Protein 3g	

Vitamin A	80%	Vitamin C	60%
Calcium	4%	Iron	4%

* Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

	Calories	2,000	2,500
Total Fat	Less than	65g	80g
Sat Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Fiber		25g	30g

Calories per gram:
Fat 9 • Carbohydrate 4 • Protein 4

- Locate Serving Size
- Locate total grams of carbohydrate
- Rules for fiber and sugar alcohols

Fiber and Sugar Alcohols

- For example:

Total Carbohydrate 30 grams

Dietary Fiber 10 grams

30 grams (Total Carbohydrate)

- 5 grams (half of dietary fiber)

25 grams of Carb to count

- The same rule applies for sugar alcohol

Nutrition Facts

Serving Size 1 cup (228g)
Servings Per Container 2

Amount Per Serving	
Calories 270	Calories from fat 126
	% Daily Value*
Total Fat 14g	21%
Saturated Fat 4g	20%
Trans Fat 1g	
Cholesterol 28mg	9%
Sodium 650mg	27%
Total Carbohydrate 30g	10%
Dietary Fiber 10 g	40%
Sugar 10g	
Sugar Alcohol 6g	
Protein 5g	

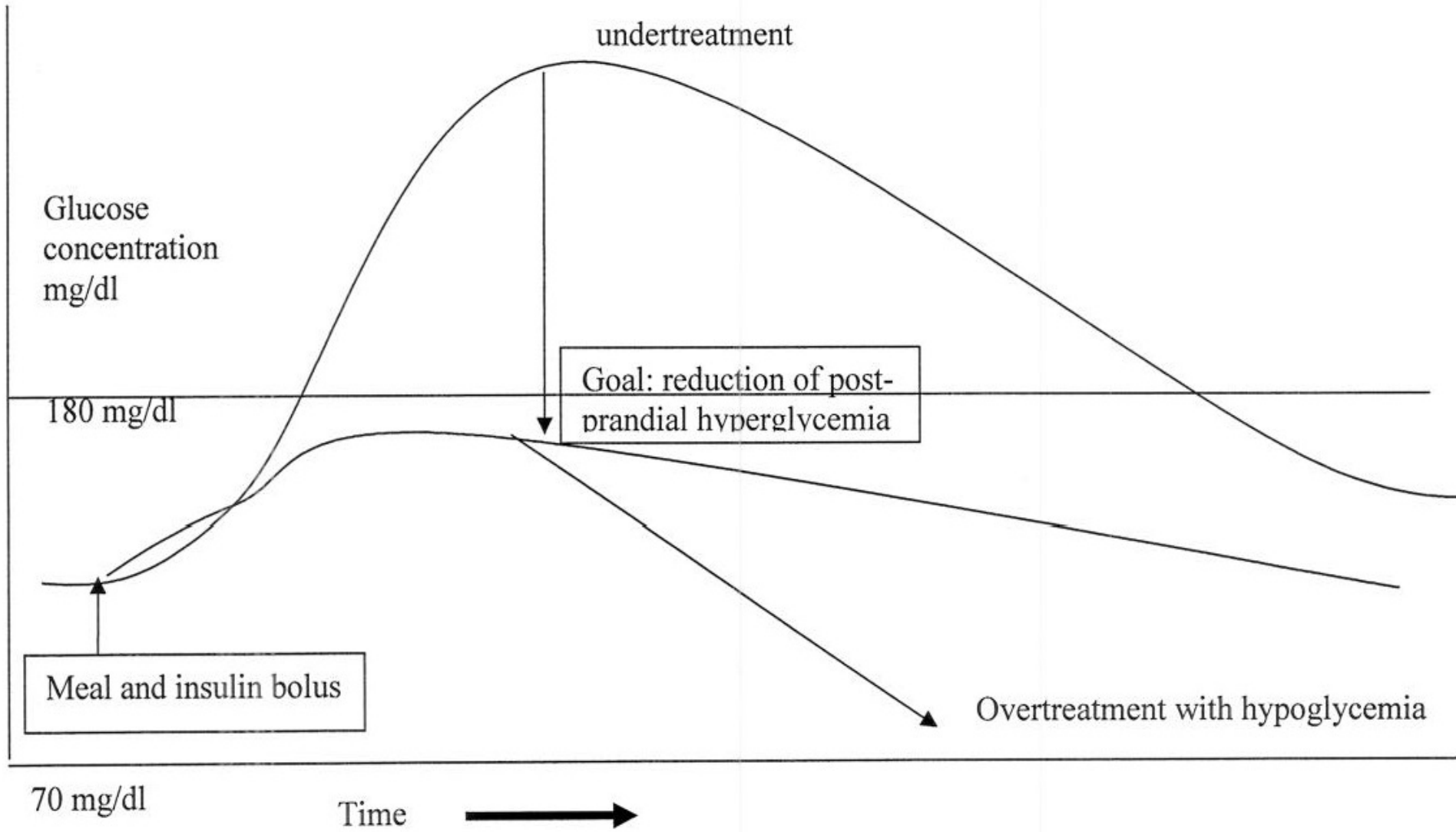
Vitamin A	4% •	Vitamin C	2%
Calcium	15% •	Iron	4%

* Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs.

	Calories	2,000	2,500
Total Fat	Less than	65g	80g
Sat. Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Calories per gram:
Fat 9 • Carbohydrate 4 • Protein 4

Figure A: Relationship of meal carbohydrate intake, insulin bolus, and post-prandial glycemic elevations



Calculating a Dose

3 Step Process

1st Step: Insulin to Carb Ratio

Determine how much insulin is needed for carbs eaten at meal or snack:

- Count up total carb grams
- Divide total grams by ratio

Calculating a Dose

2nd Step: Blood Glucose Correction

Determine How Much Insulin is Needed to correct blood sugar (bg) to target

- Check bg
- Calculate insulin amount needed to bring bg into target range (i.e. … 1 unit per 50 over 150- Individualized)

3rd Step: Total Dose = Insulin needed for carbs plus insulin needed for bg

Estimation of prandidal insulin

- **Rule of 500: Carb factor**

500 : TDD = g Carbs " covered " by 1Units short acting analogue insulin

Example:
CDO = 25 U
500 : 25 = 20 → 1 E covered 20 g Carbs

How to calculate insulin dose by counting <u>Grams of Carbs</u>

Insulin prescribed by MD:

"1 unit of insulin for every 15 grams of Carb"

1 burger patty

+

1 hamburger bun

+

½ cup peas

+

1 small apple

- How many grams of Carb is in this meal?

60

- How many units of insulin are needed?

60 grams of Carb ÷ 15 = 4 units of insulin

FIT TESTS

OPIS OBROKA — **ZAJTRK** — Datum: 27.03.2007

KRUH 40g 20g	1. 1 enota za 11,1 g OH	0 h 7,2
JOGURT 100g 5g	2. Količina OH 25 g	1 h 8,6
SALAMA 11g /	3. Bolus: 2,2 = 2 E	2 h 5,7
25g		3 h 4,6
		4 h 5,4

OPIS OBROKA — **KOSILO** — Datum: 26.03.2007

SOLATA 70g 1,7g	1. 1 enota za 11,1 g OH	0 h 4,9
PAPRIKA 32g 1,0g	2. Količina OH 43 g	1 h 7,2
KROMPIR 215g 40,3g	3. Bolus: 4 E	2 h 7,4
SVIŽREZEK 46g /		3 h 8,0
43g		4 h 7,2

OPIS OBROKA — **VEČERJA** — Datum: 26.3.07

K. KUMARICA 25g /	1. 1 enota za 11,1 g OH	0 h 7,2
KRUH 66g 33g	2. Količina OH 33 g	1 h 9,8
MORTADELA 26g /	3. Bolus: 2,9 = 3 E	2 h 6,6
SIR 7g /		3 h 4,9
33g		4 h 4,1

± 20

41

Datum 13.3

Noč	Dopoldan	Popoldan	Večer
14 Lantus 11.30	12.3.	10.13 4.6	16.3
Po večerji 8,1	6 h 6,8	12 h 8,3	19 h 7,7
24 h 10,3	7 h 6,8	13 h 4,8	20 h 6,8
3 h 14,3	8 h 7,3	14 h 4,1	21 h 6,1
6 h 10,5	9 h 10,1	15 h 4,0	22 h 4,7 ?
8 h 9,1	10 h 7,7 ?	16 h 3,9 ?	23 h 6,7
	11 h 11,0	17 h 3,2	24 h 6,8
	12 h 11,2	18 h	
		19 h	

LT 14 + 13

Datum

Noč	Dopoldan	Popoldan	Večer
20.4.2007	28.3.2007	12.4.2007	16.14 5.6 24.
Lantus 11.30			13 7,5
Po večerji 7,9	6 h 5,7	12 h 8,1	19 h 7,9
24 h 11,2	7 h 4,6	13 h 7,1	20 h 9,1
3 h 8,9	8 h 5,7	14 h 6,5	21 h 12,4
6 h 6,2	9 h 10,8	15 h 8,2	22 h 14,2
8 h 7,7	10 h 12,2	16 h 7,1	23 h 14,4
	11 h 13,4	17 h 8,4	24 h 12,4
	12 h 14,2	18 h 9,1	
		19 h	

22. 5. ob 14.00

The evidence…

- DAFNE study: course teaching flexible intensive insulin treatment combining with dietary freedom and insulin adjustment
  - Improved A1c at 6 months (9.4% v. 8.4%, $p<0.0001$)
  - Improved 'quality of life' at one year

DCCT study: using CHO/insulin ratios in intensively treated group improved glycemic control

DAFNE
Dose Adjustment For Normal Eating

The aim of the programme is for participants to eat freely, and adjust their insulin to match carbohydrate load, physical activity and insulin sensitivity.

DAFNE
Dose Adjustment For Normal Eating

- A course adapted from the Michael Berger's 'Diabetes Training and Treatment Programme' for people with Type 1 diabetes and started in the UK from 2000.

- Intensive group education taking place over 5 consecutive days with a skills based focus.

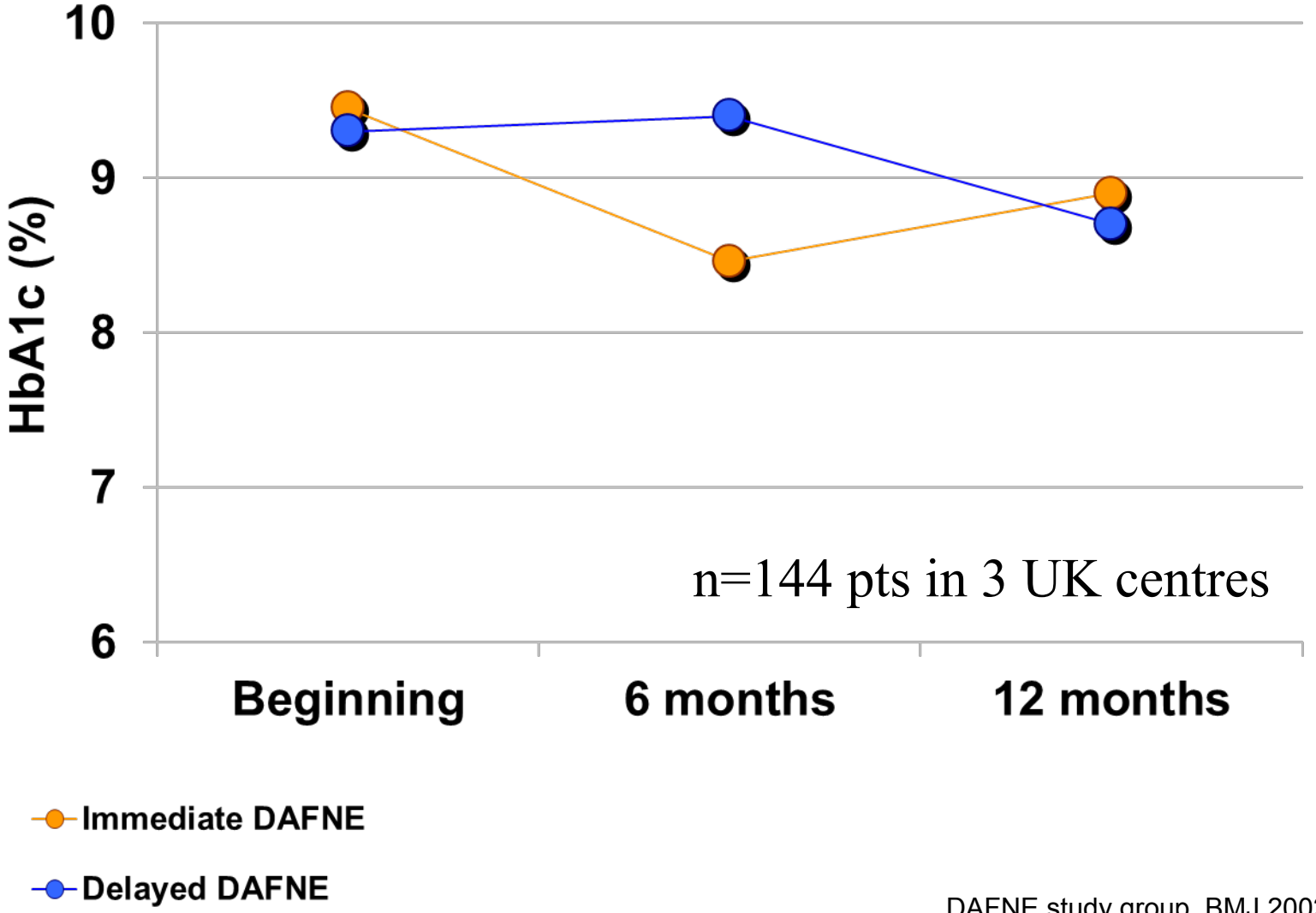
- Led by Diabetes Specialist Nurse and Dietitian.

- Normally 6 to 8 participants per group.

DAFNE timetable

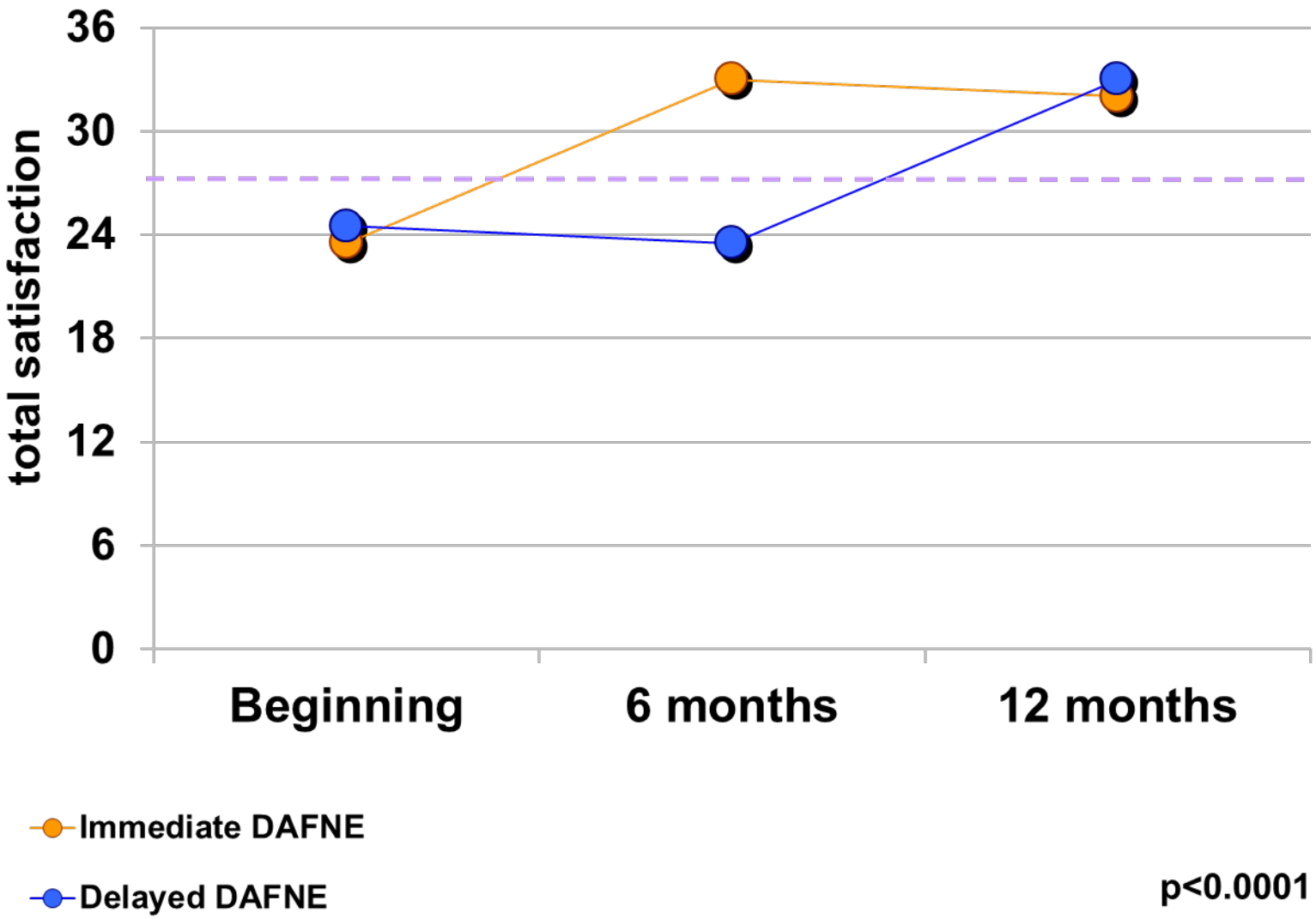
Monday	Tuesday	Wednesday	Thursday	Friday
09.15 - 09.45 Introduction **09.45 - 10.45** What is diabetes?	**09.15 - 10.30** Discussion: Individual blood glucose levels `	**09.15 - 10.30** Group discussion: Glucose levels	**09.15 - 10.30** Group discussion: Glucose levels	**09.15 - 10.30** Group discussion: Glucose levels
10.45 - 11.00 Coffee	***10.30 - 10.45 Coffee***	***10.30 - 10.45 Coffee***	***10.30 - 10.45 Coffee***	***10.30 - 10.45 Coffee***
11.00 - 12.30 Nutrition 1 •Identify carbohydrates	**10.45 - 12.30** DAFNE insulin adjustment	**10.45 - 12.30** Hypoglycaemia	**10.45 - 12.30** Nutrition 4 •Alcohol •Eating out •Healthy eating/ weight control	**10.45 - 11.45** Sick day rules **11.45 - 12.30** Social aspects (Contraception and pregnancy – optional)
12.30 - 13.30 Lunch	***12.30 - 13.30 Lunch***	***12.30 - 13.30 Lunch***	***12.30 - 13.30 Lunch***	***12.30 - 13.30 Lunch***
13.30 - 15.00 All about insulin	**13.30 - 15.00** Nutrition 2 •Putting carbohydrate estimation into practice	**13.30 - 15.00** Nutrition 3 •Food packaging •Recipes	**13.30 - 15.00** Annual review and screening	**13.30 - 14.30** Quiz **14.30 - 15.30** Evaluation and follow up arrangements
15.00 - 15.15 *Coffee*	**15.00 - 15.15 *Coffee***	**15.00 - 15.15 *Coffee***	**15.00 - 15.15 *Coffee***	***Close***
15.15 - 17.00 New insulin regime and individual targets	**15.15 - 16.15** Self monitoring	**15.15 - 16.15** Managing physical activity	**15.15 - 16.15** Questions for the Doctor	
	16.15 - 17.00 Discussion: Individual blood glucose levels	**16.15 - 17.00** Group dose adjustment session	**16.15 - 17.00** Group dose adjustment session	

UK DAFNE Study



DAFNE study group. BMJ 2002

Results: DTSQ



p<0.0001

DAFNE study group. BMJ 2002

How does it work in our center?

I FEEL SLOVENIA

I feel Slovenija
Country brand

Population: 2,054,199

Area: 20,273 km^2

DIABETES FACTS

Population: 135.000

Type 1 DM: 6.000

Prevalence: 6.9%

- Started in 2003
- 1440 type 1 diabetic pts.
- Age 18-65

- Education taking place over 3 consecutive days.
- Normally 3-4 participants per group.

- Offered to anyone who needs/wants to improve self-management skills.
- Offered to all newly-diagnosed patients.

- Led by diabetes specialist nurse and diabetologist.

- N= 180 pts
- mean age 38±10y
- duration diabetes 17±10y

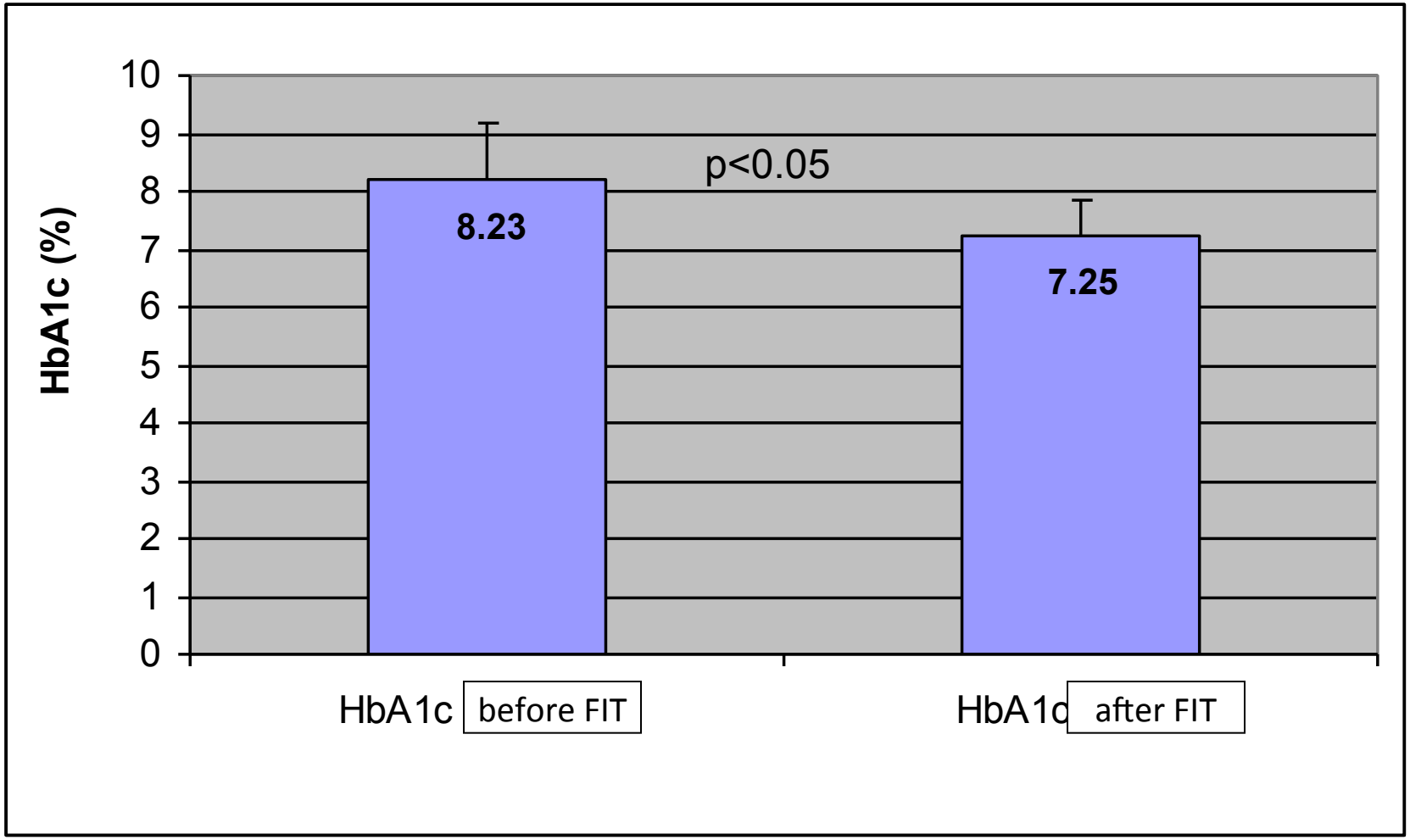
- Hba1c 8.23 ± 0.8% (3 values 1 year before FIT)

↓

- 3 values of HbA1c 1 year after FIT

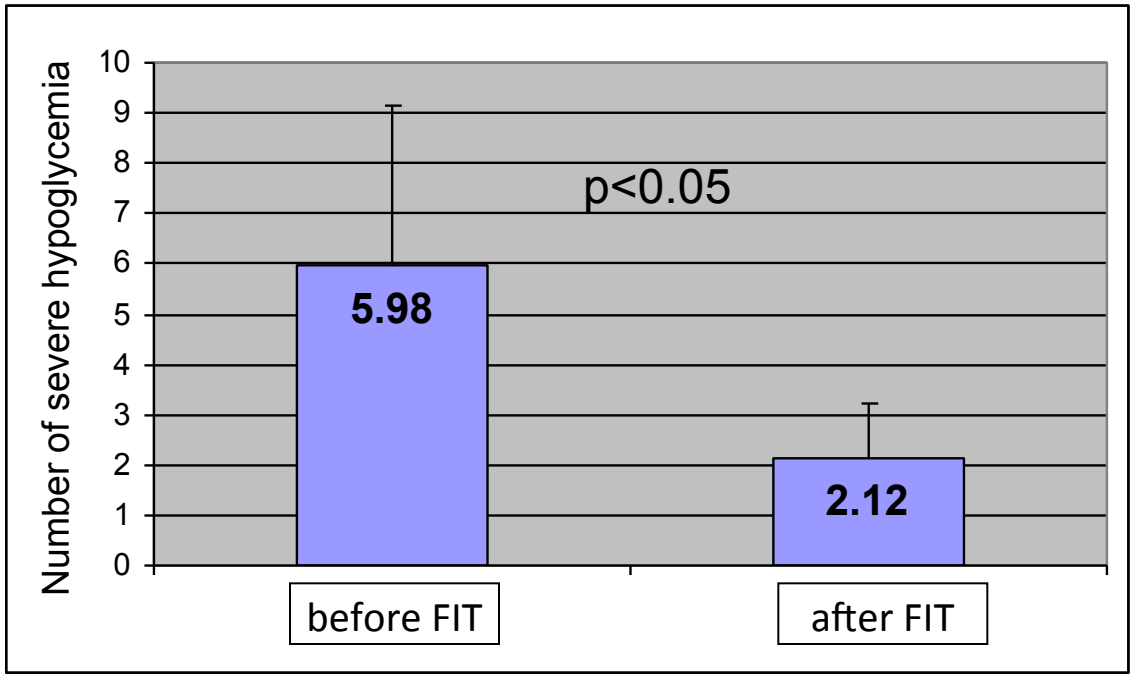
Janez A et al. Diabetes 2007; 56; Suppl 1.

Effect of FIT on HbA1c



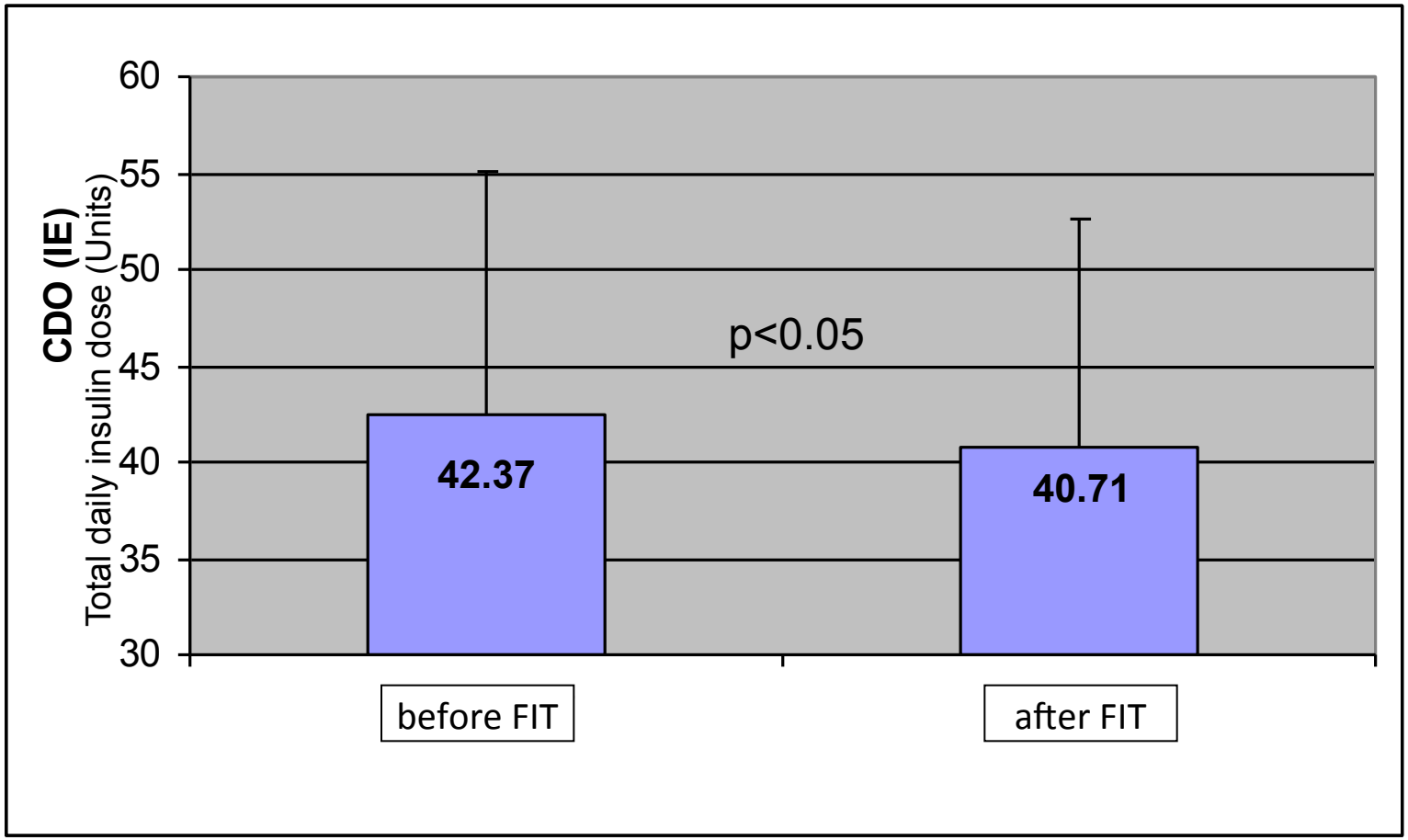
Janez A et al. Diabetes 2007; 56; Suppl 1.

Effect of FIT on severe hypoglycemia



Janez A et al. Diabetes 2007; 56; Suppl 1.

Effect of FIT on total daily insulin dose



Janez A et al. Diabetes 2007; 56; Suppl 1.

The Journal of International Medical Research
2012; 40: 1546 – 1551

Continuous Subcutaneous Insulin Infusion in Adult Type 1 Diabetes Mellitus: Data from a Registry at the University Medical Centre Ljubljana, Slovenia

TABLE 1:
Demographic and clinical characteristics of patients with type 1 diabetes who were treated with continuous subcutaneous insulin infusion (CSII) and included in the present comparison of CSII with multiple daily injection (MDI) insulin treatment (*n* = 184)

Age at initiation of CSII, years	39.4 ± 10.7
Diabetes duration prior to CSII, years	15.7 ± 9.4
CSII duration, years	3.8 ± 0.3
Body weight, kg	73.2 ± 14.8
Body mass index, kg/m^2	25.9 ± 5.6
Indication for starting CSII	
Insufficient glycaemic control	79 (43)
Trying to conceive/pregnant	52 (28)
Unawareness of hypoglycaemia	46 (25)
Dawn phenomenon	7 (4)

Data presented as mean ± SD, or *n* (%) of patients.

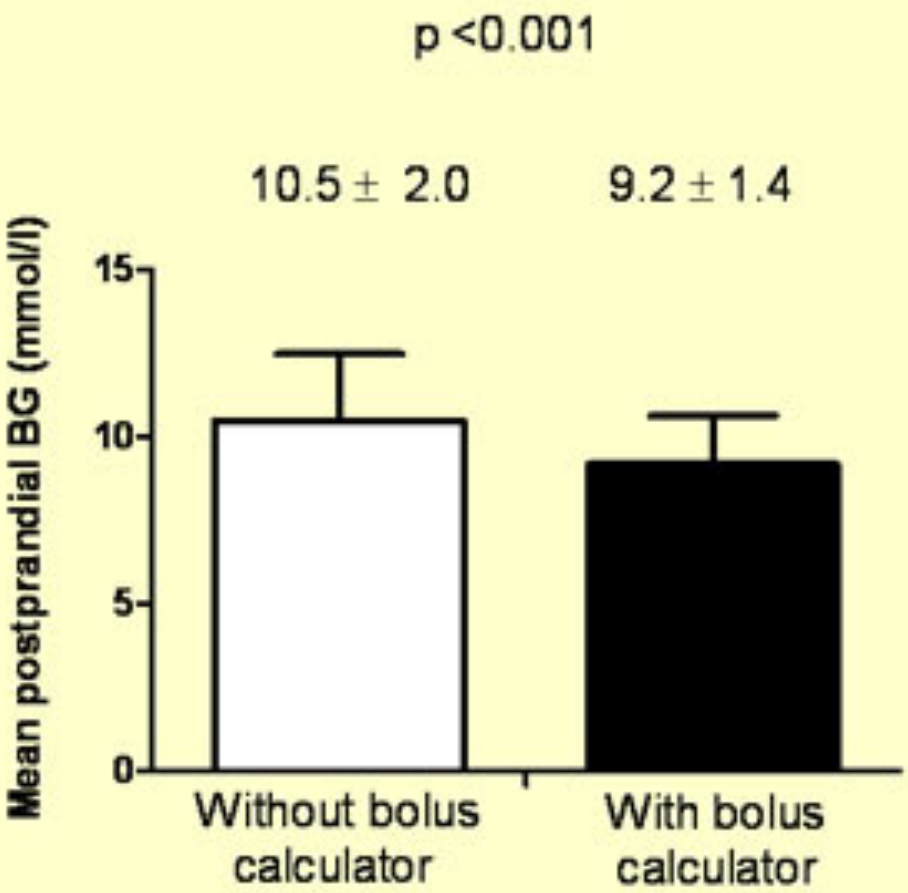
TABLE 3:
Glycosylated haemoglobin (HbA_{1c}) levels and total daily insulin dose over a period of 3 years in patients with type 1 diabetes after changing from multiple daily injection (MDI) insulin therapy to continuous subcutaneous insulin infusion (CSII) (*n* = 184)

		CSII		
Parameters	MDI	After 1 year	After 2 years	After 3 years
HbA_{1c}, %	7.6 ± 0.9	6.9 ± 0.9***	6.9 ± 0.6***	7.0 ± 0.6***
Total insulin, IU/day	48.9 ± 16.2	38.5 ± 15.3***	38.7 ± 12.3***	38.1 ± 14.4***

Data presented as mean ± SD.
***$P < 0.001$ versus MDI (Student's *t*-test).

Janez A. J Int Med Res. 2012;40(4):1546-51.

Use of bolus calculator reduces postprandial blood glucose

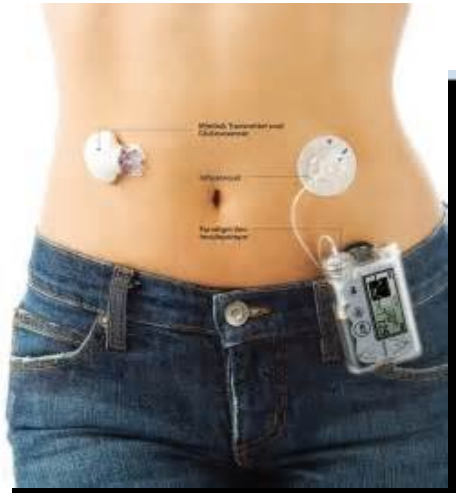


36 type 1 diabetic patients randomised to bolus calculator or usual meal bolus dosing for 2 weeks

Shashaj et al Diabetic Med 2008; 25: 1036-42

Integrated bolus calculators in insulin pumps

- Introduced in 2002
- Calculate bolus dose based on:
  - Premeal BG
  - Target BG
  - Intended CHO intake
  - I:C ratio and ISF
  - Insulin 'on board' or active insulin (amount remaining from previous bolus)

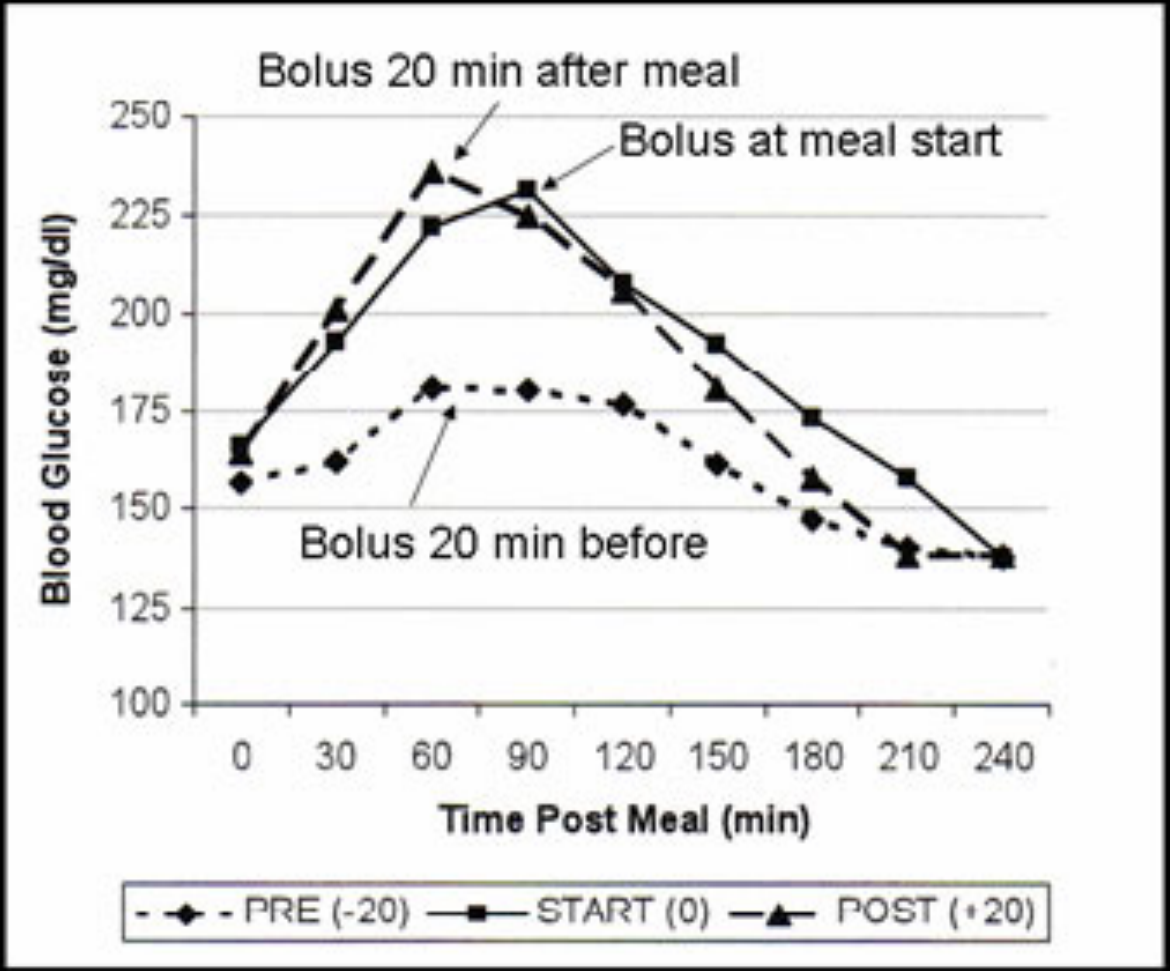


Timing of meal-time bolus

Most patients using CSII with monomeric insulin give meal insulin bolus at start of meal

or even after meal

Bolus 20 min prior to meal reduces postprandial hyperglycaemia



23 type 1 DM patients using CSII with glulisine

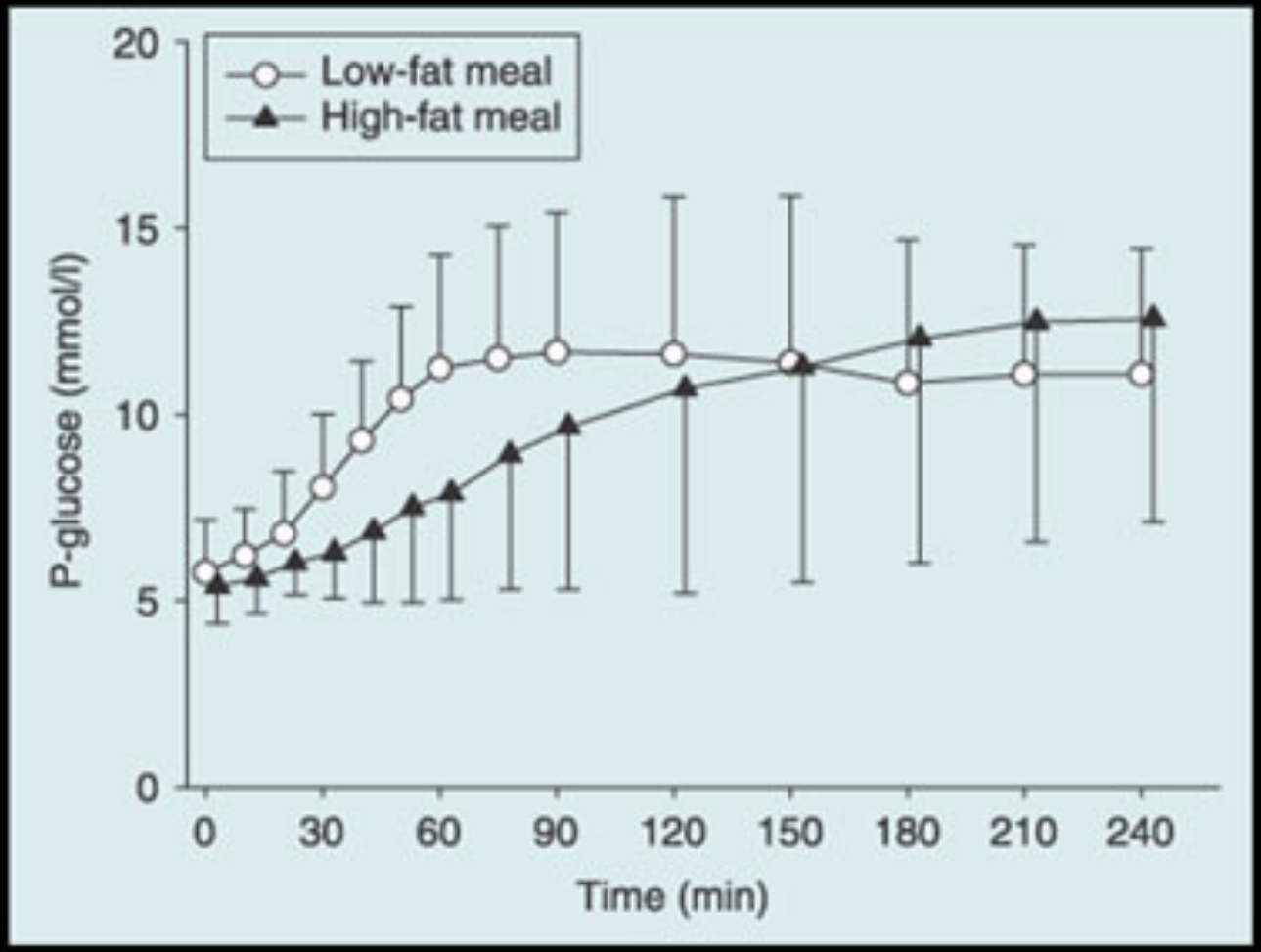
Cobry et al Diabetes Technol Ther 2010; 12: 173-177

Giving meal insulin bolus
~15-20 min before meal start
improves control in many patients

Influence of food type

Fatty meals

High fat meals delay gastric emptying and may cause insulin resistance and late hyperglycaemia



Lodefalk et al Diabetic Med 2008; 25: 1030-1035

Bolus types

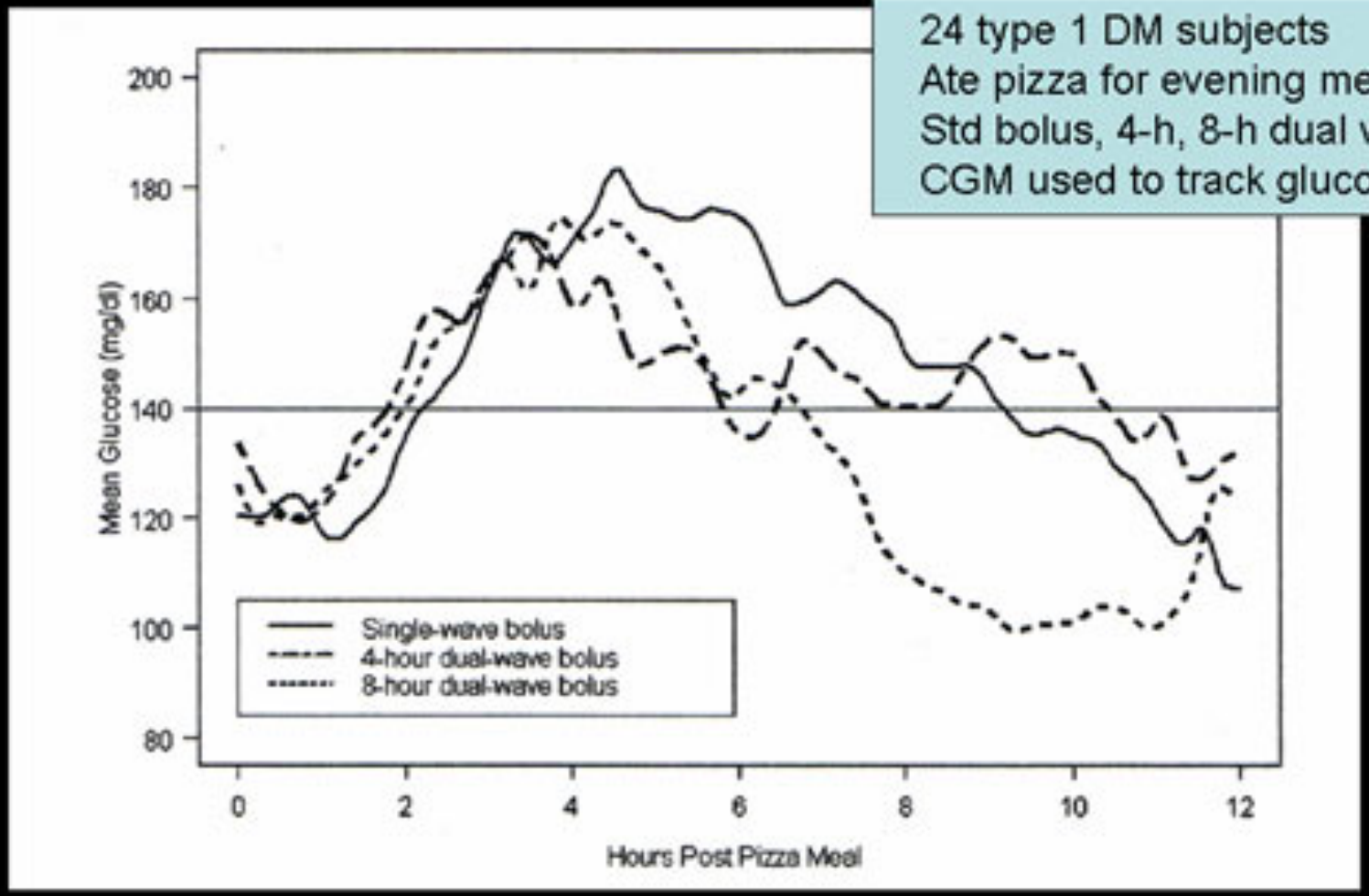
Standard or single bolus

Two boluses

Extended or square wave

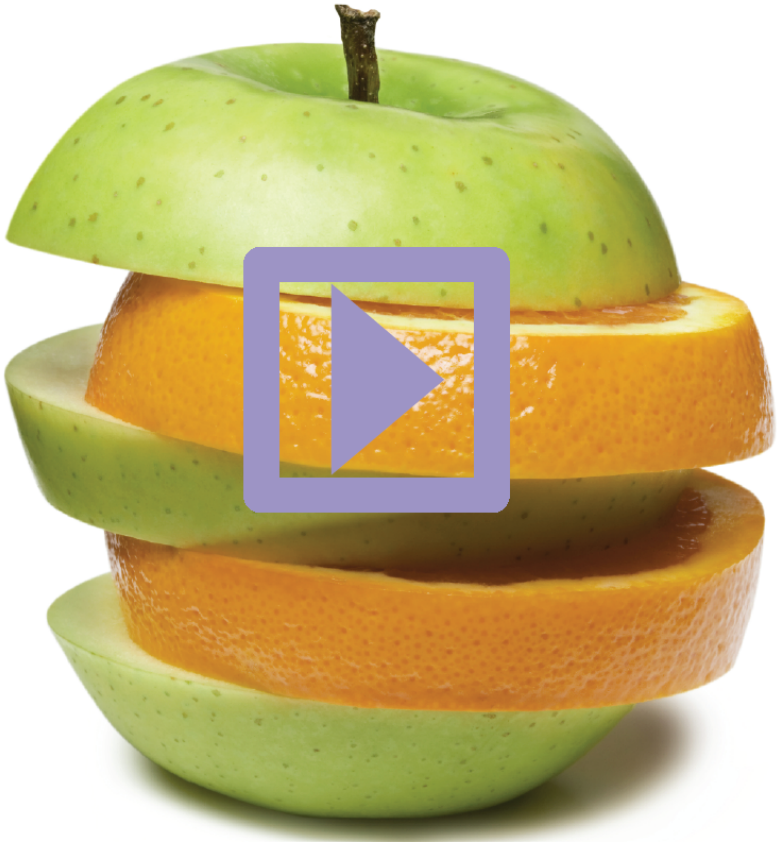
Dual or combination wave

Dual-wave bolus reduces postprandial hyperglycaemia after a fatty meal



Jones SM et al. Diabetes Technol Ther 2005; 233-239

Vem, kaj jem!®




Si.mobil 3G 22:06 97%
Vem,
kaj jem!®
simobil.si
SANOFI DIABETES


Si.mobil 3G 22:11 98%
Vem, kaj jem!
Danes
Dodaj obrok
Moji obroki
14g Beljakovine 3%
18g Og. hidr. 4%
9g Maščobe 4%
187 Kalorije 10%
1971
Vem, kaj jem!
Moje zdravje
Statistika
Poročilo
Nastavitve


Si.mobil 3G 22:09 98%
Nazaj
Vem, kaj jem!
Vnesi naziv hrane oz. jedi
Sola
CEZARJEVA SOLATA BREZ PIŠČANCA, MCDONALD'S
CEZARJEVA SOLATA S PIŠČANCEM, MCDONALD'S
SADNA SOLATA, KOMPOT, V GOSTEM SOKU
SADNA SOLATA, KOMPOT, V LAHKEM SOKU
SADNA SOLATA, KOMPOT, V SOKU
Vem, kaj jem!
Moje zdravje
Statistika
Poročilo
Nastavitve

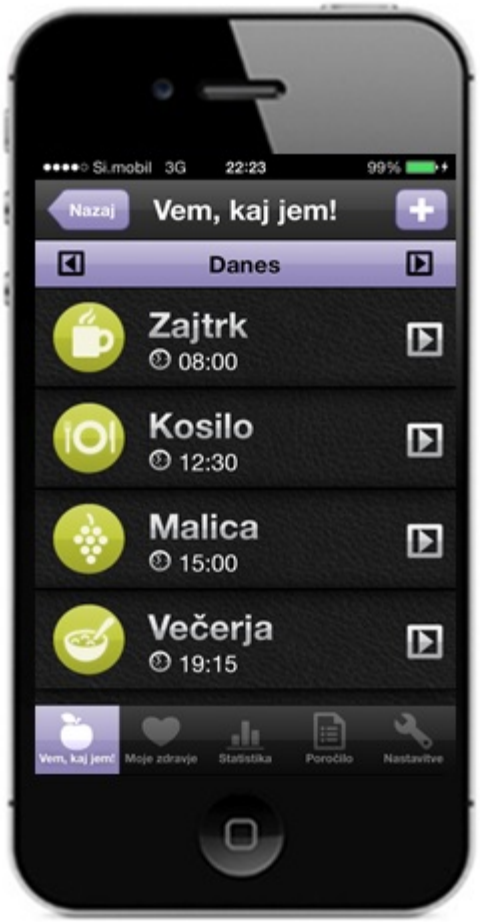

Si.mobil 3G 22:09 98%
Nazaj
Vem, kaj jem!
Zajtrk
Kosilo
Večerja
Malica
Kdaj 22:06
Izberi hrano
Izbrane jedi
CEZARJEVA SOLATA BREZ PIŠČANCA, MCDONALD'S
2x kos
Vem, kaj jem!
Moje zdravje
Statistika
Poročilo
Nastavitve


Si.mobil 3G 22:09 98%
Nazaj
Vem, kaj jem!
Zajtrk
Kosilo
Večerja
Malica
PODATKI O HRANI
Maščobe: 9
Og. hidr.: 18
Beljakovine: 14
Kalorije: 187
Izbrane jedi
CEZARJEVA SOLATA BREZ PIŠČANCA, MCDONALD'S
2x kos
Vem, kaj jem!
Moje zdravje
Statistika
Poročilo
Nastavitve

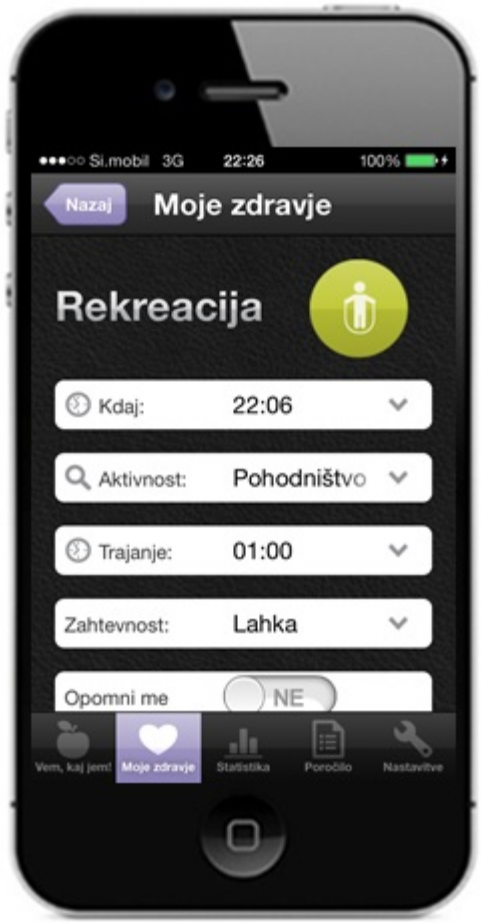

Si.mobil 3G 22:27 100%
Nazaj
Moje zdravje
Insulin
Odmerek (enot):
Kdaj: 22:06
Insulin: Kratkodelujoči
Vnos
Vem, kaj jem!
Moje zdravje
Statistika
Poročilo
Nastavitve

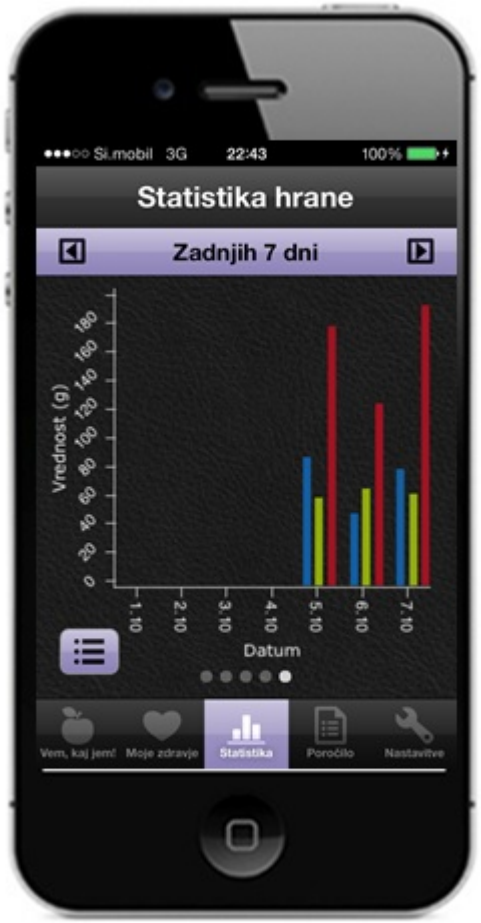

2in1


Si.mobil 3G 22:27 100%
Nazaj
Moje zdravje
Krvni sladkor
Vrednost (mmol/l):
Kdaj: 22:06
Vnos
Vem, kaj jem!
Moje zdravje
Statistika
Poročilo
Nastavitve


Si.mobil 3G 22:23 99%
Nazaj
Vem, kaj jem!
Danes
Zajtrk
08:00
Kosilo
12:30
Malica
15:00
Večerja
19:15
Vem, kaj jem!
Moje zdravje
Statistika
Poročilo
Nastavitve


Si.mobil 3G 22:26 100%
Moje zdravje
Dodaj
Danes
Rekreacija
Teža
Krvni sladkor
Odmerek insulina
Rekreacije
Kolesarjenje - 120 min
Tenis - 60 min
Vem, kaj jem!
Moje zdravje
Statistika
Poročilo
Nastavitve


Si.mobil 3G 22:26 100%
Nazaj
Moje zdravje
Rekreacija
Kdaj: 22:06
Aktivnost: Pohodništvo
Trajanje: 01:00
Zahtevnost: Lahka
Opomni me
NE
Vem, kaj jem!
Moje zdravje
Statistika
Poročilo
Nastavitve


Si.mobil 3G 22:43 100%
Statistika hrane
Zadnjih 7 dni
Vrednost (g)
0
20
40
60
80
100
120
140
160
180
1.10
2.10
3.10
4.10
5.10
6.10
7.10
Datum
Vem, kaj jem!
Moje zdravje
Statistika
Poročilo
Nastavitve

Conclusions…

- All people with Type 1 diabetes (also type 2 with basal-bolus therapy) should be offered a structured FIT education course.
- Carbohydrate counting is an important skill for all involved.
- FIT outcomes: lower HbA1c, no increase or even reduced sever hypos, better QoL.

Thank you !