Type 1 Diabetes: Managing Challenging Meals

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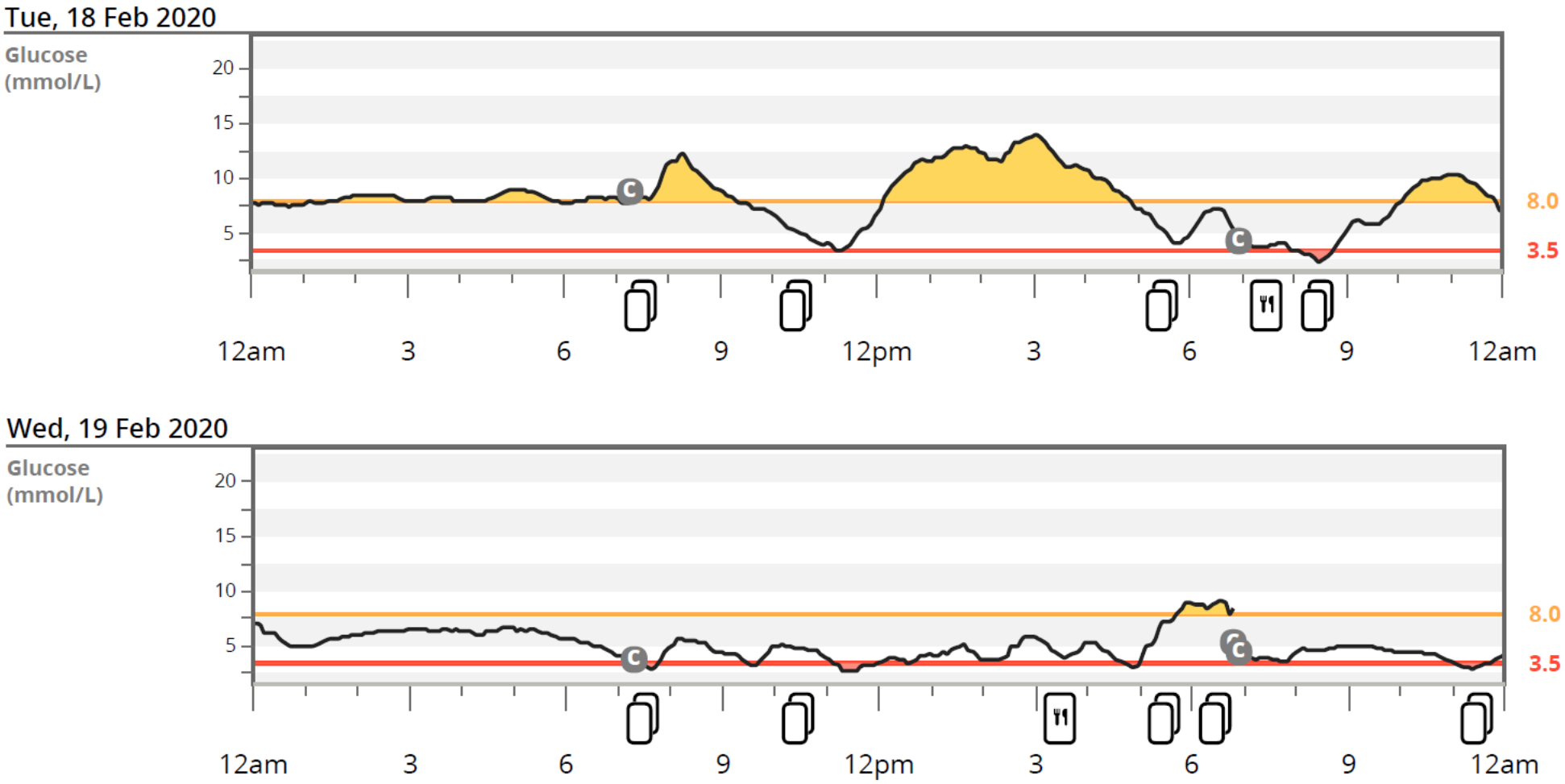
Carb, fat, protein or dietary behaviours?



Objectives

1. Discuss the impact of protein and fat on blood glucose levels in people with type 1 diabetes

2. Identify strategies for insulin dosing for protein and fat for different insulin therapies

Carb counting is an imperfect method

- **<u>Carbohydrate counting</u>** is current standard of practice- yet it is an imperfect method.
- **Postprandial hyperglycaemia is a major issue.**

Diabetes Sci Technol, 2017

Accurate Carbohydrate Counting Is an Important Determinant of Postprandial Glycemia in Children and Adolescents With Type 1 Diabetes on Insulin Pump Therapy

Asma Deeb, MBBS, MD,[1] Ahlam Al Hajeri, RD,[1] Iman Alhmoudi, MBBS,[1] and Nico Nagelkerke, PhD[2]

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The missing piece of the puzzle: dietary fat and protein

Influence of dietary protein on postprandial blood glucose levels in individuals with Type 1 diabetes mellitus using intensive insulin therapy

M. A. Paterson[1,2], C. E. M. Smart[1,3], P. E. Lopez[1,2], P. McElduff[1], J. Attia[1], C. Morbey[4] and B. R. King[2,3]

Higher glucose concentrations following protein- and fat-rich meals – the Tuebingen Grill Study: a pilot study in adolescents with type 1 diabetes

Dietary Fat Acutely Increases Glucose Concentrations and Insulin Requirements in Patients With Type 1 Diabetes

Howard A. Wolpert, MD[1,2]
Astrid Atakov-Castillo, BA[1]
Stephanie A. Smith, MPH[1]
Garry M. Steil, PhD[2,3]

Does the Fat-Protein Meal Increase Postprandial Glucose Level in Type 1 Diabetes Patients on Insulin Pump: The Conclusion of a Randomized Study

Both Dietary Protein and Fat Increase Postprandial Glucose Excursions in Children With Type 1 Diabetes, and the Effect Is Additive

Carmel E.M. Smart, RD, PhD[1,2]
Megan Evans, RD, PGradDipDiet[3]
Susan M. O'Connell, MD, FRACP[3,4]
Patrick McElduff, PhD[2]
Prudence E. Lopez, MD[2,5]
Timothy W. Jones, MD, FRACP[3,4,6]
Elizabeth A. Davis, MD, PhD[3,4,6]
Bruce R. King, MD, PhD[1,5]

Clinical guidelines now recommend insulin dosing for carb, fat and protein

American Diabetes Association (ADA) 2020

> "Individuals in whom carbohydrate counting is effective can incorporate estimates of meal fat and protein content into their prandial dosing for added benefit"

International Society of Paediatric and Adolescent Diabetes (ISPAD) 2018

> "The impact of dietary fat and protein should be considered when determining the insulin bolus dose and delivery"

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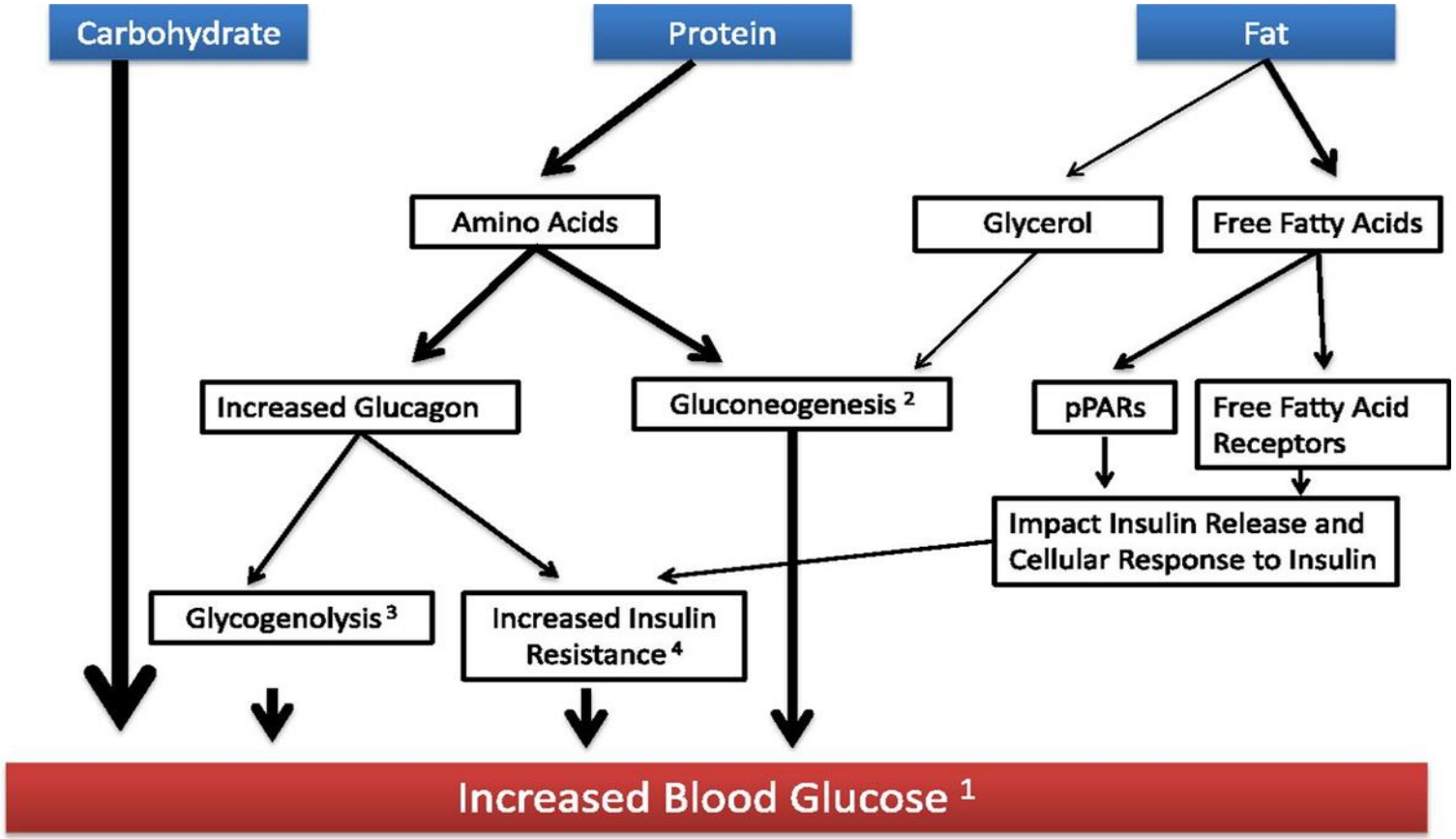
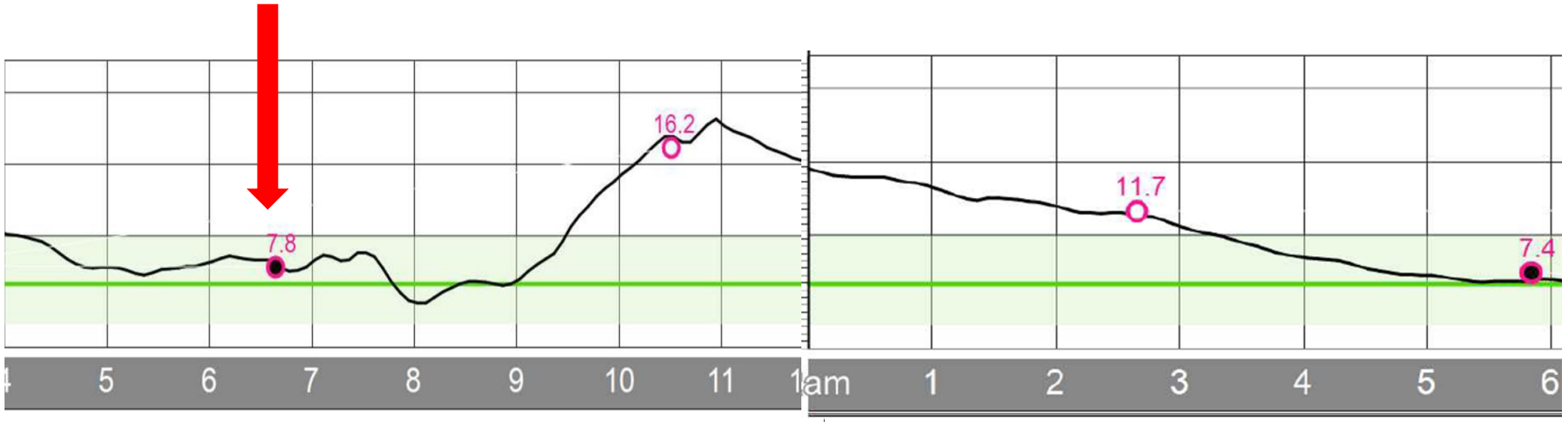
INSULIN DOSING FOR FAT AND PROTEIN
IS IT TIME ?

Carmel E.M. Smart, Bruce R. King and Prudence E. Lopez
Diabetes Care 2020;43:13-15.

MECHANISM OF FAT, PROTEIN AND CARB IMPACT

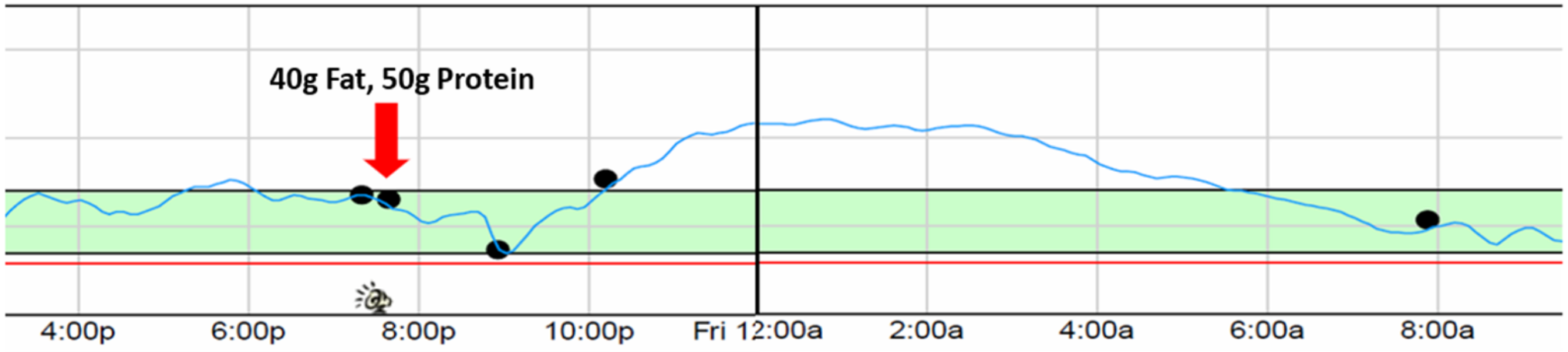


Observe impact of fat and protein with CGM

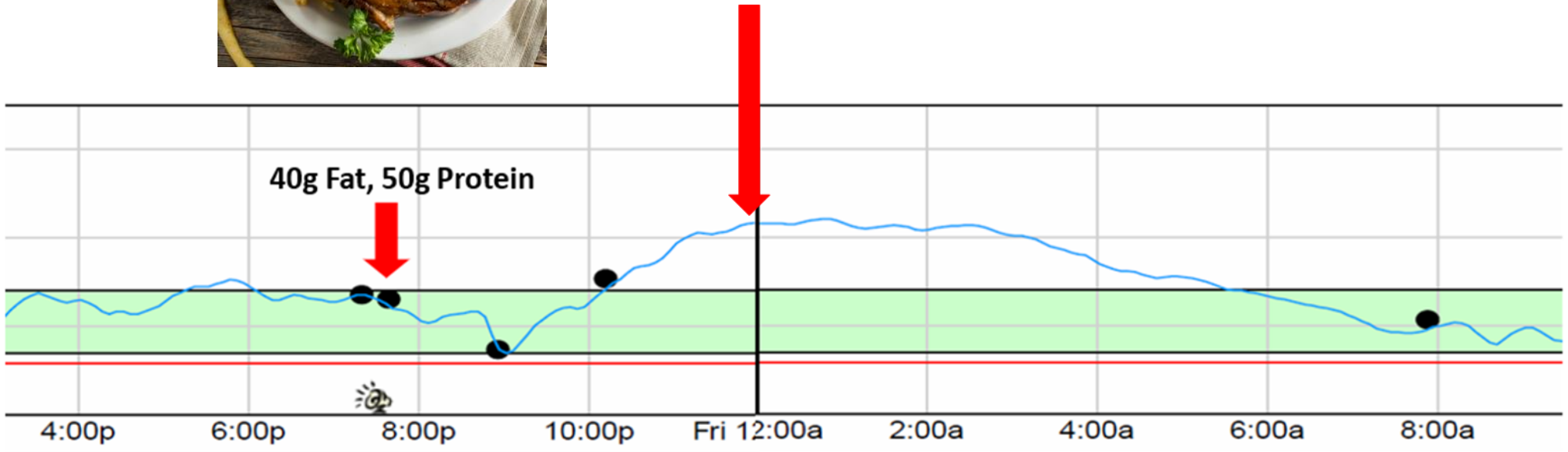


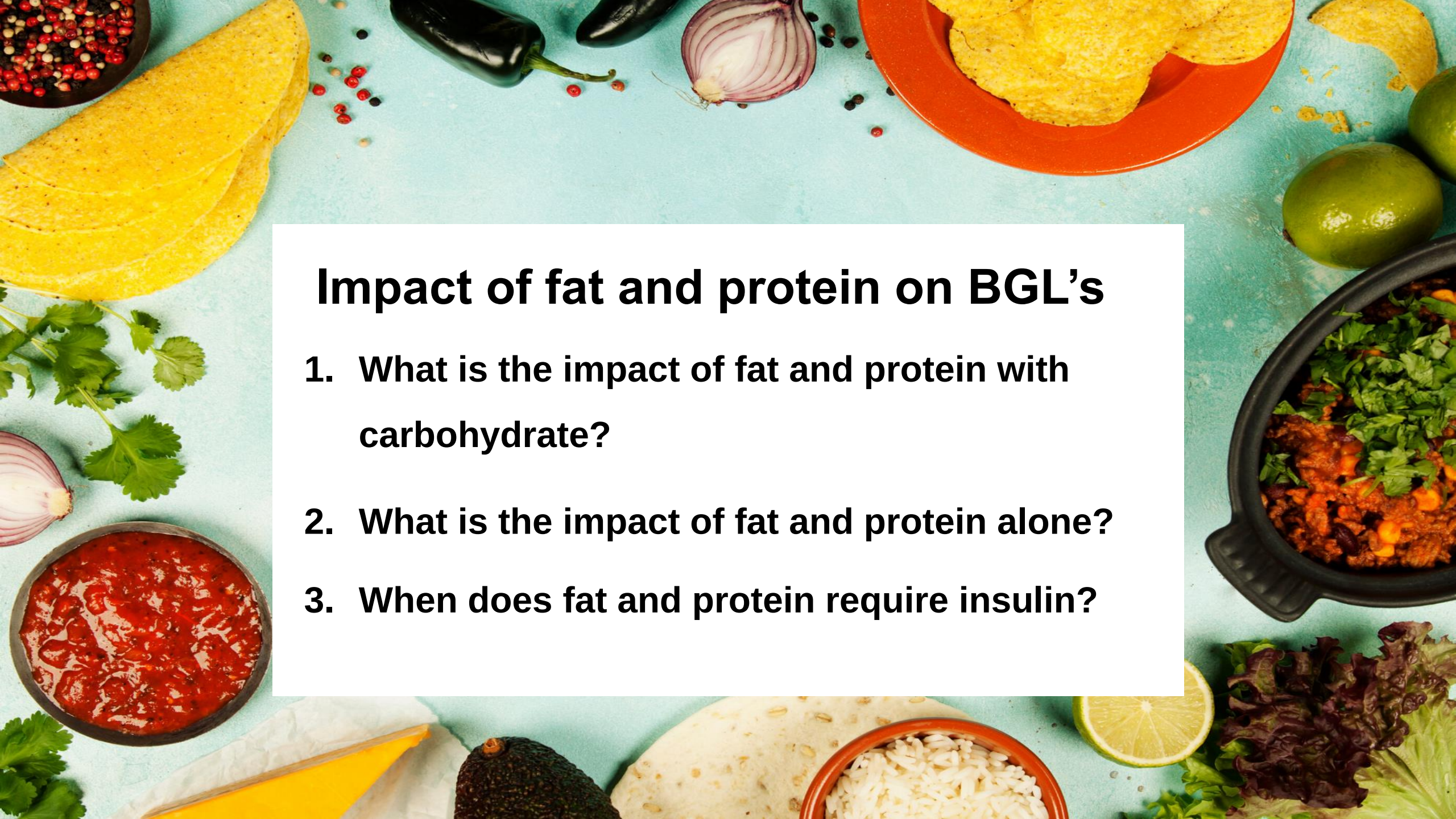
Observe impact of fat and protein with CGM

Impact of high protein, high fat meal in hybrid closed loop



Impact of high protein, high fat meal in hybrid closed loop



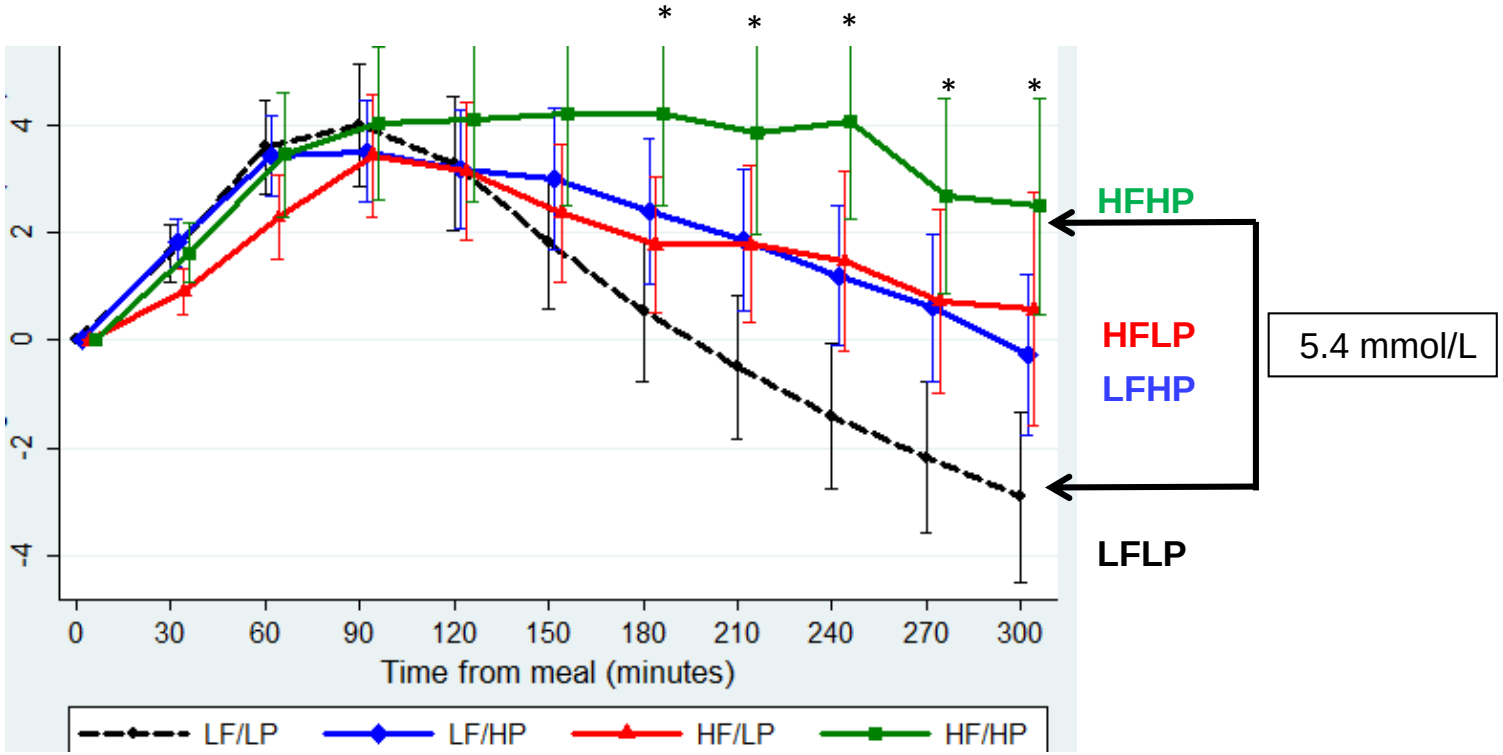


Impact of fat and protein on BGL’s

1. What is the impact of fat and protein with carbohydrate?
2. What is the impact of fat and protein alone?
3. When does fat and protein require insulin?

Fat (35g/26g) and protein (40g/30g) causes late hyperglycaemia between 180- 300 mins

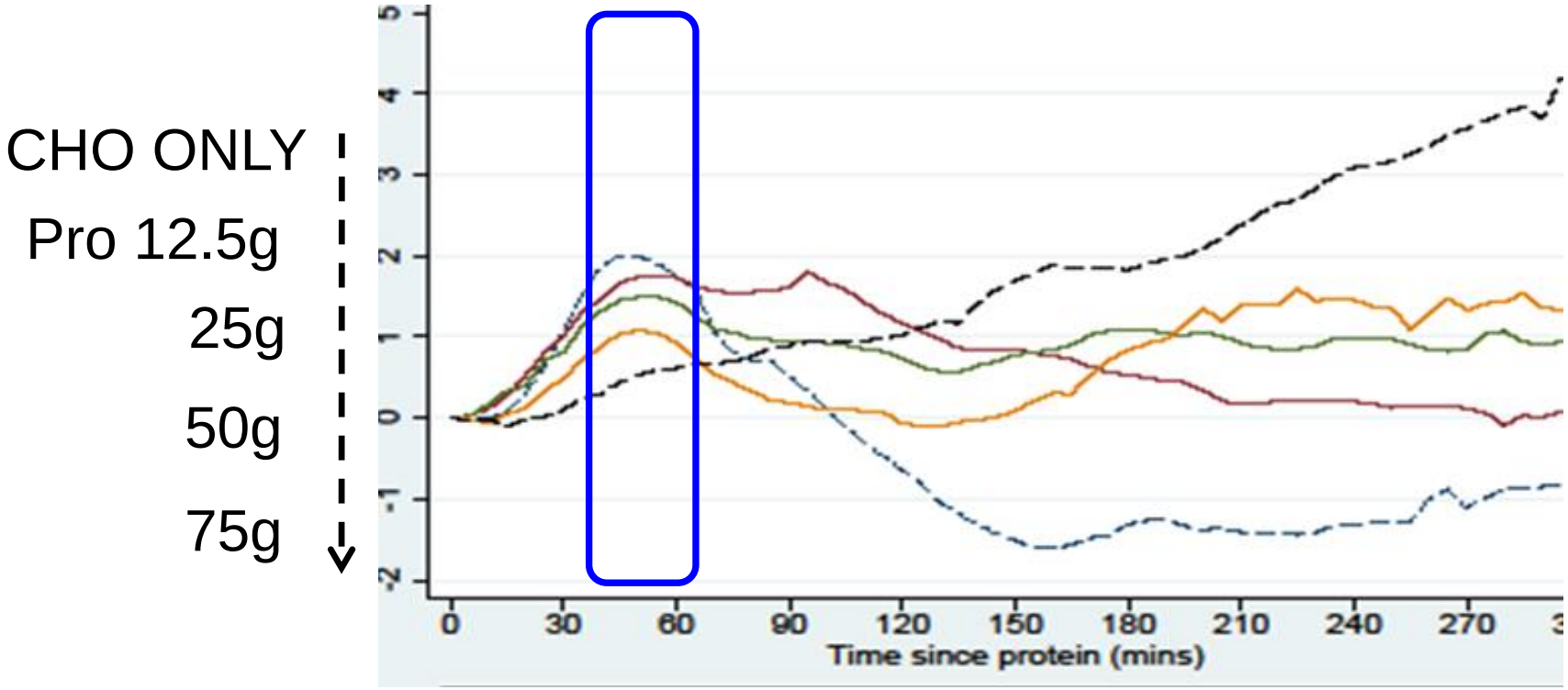
Smart *et al,* Diabetes Care, 2013



STUDY AIM: To investigate the separate and combined effects of high fat and high protein meals, all with the same carbohydrate amount, on postprandial glycaemia in children using intensive insulin therapy

Lower glucose excursions with increasing protein: 30-60 mins

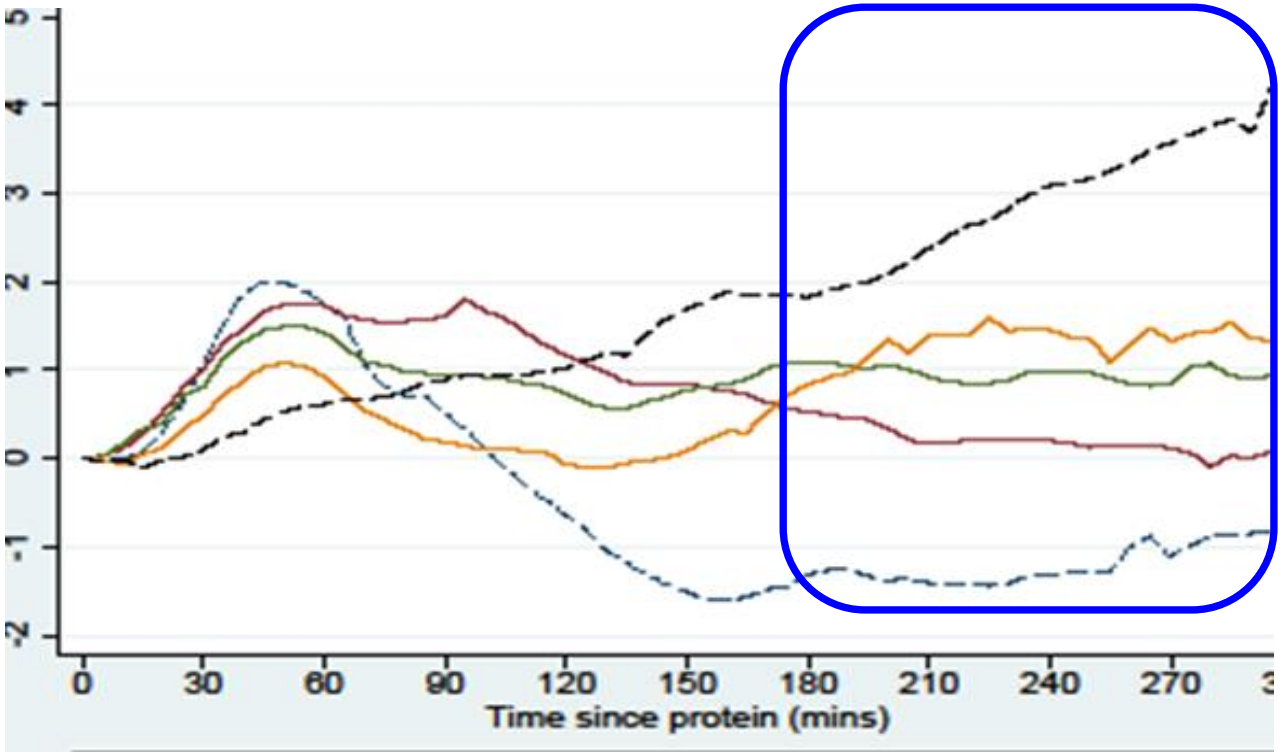
Paterson et al, Diabetes Care 2017



STUDY AIM : To determine the effects **<u>of increasing amounts of protein plus carb (30g)</u>** on postprandial glycaemia in children and adults with type 1 diabetes using intensive insulin therapy

Higher postprandial excursions with increasing protein: 180 – 300 mins

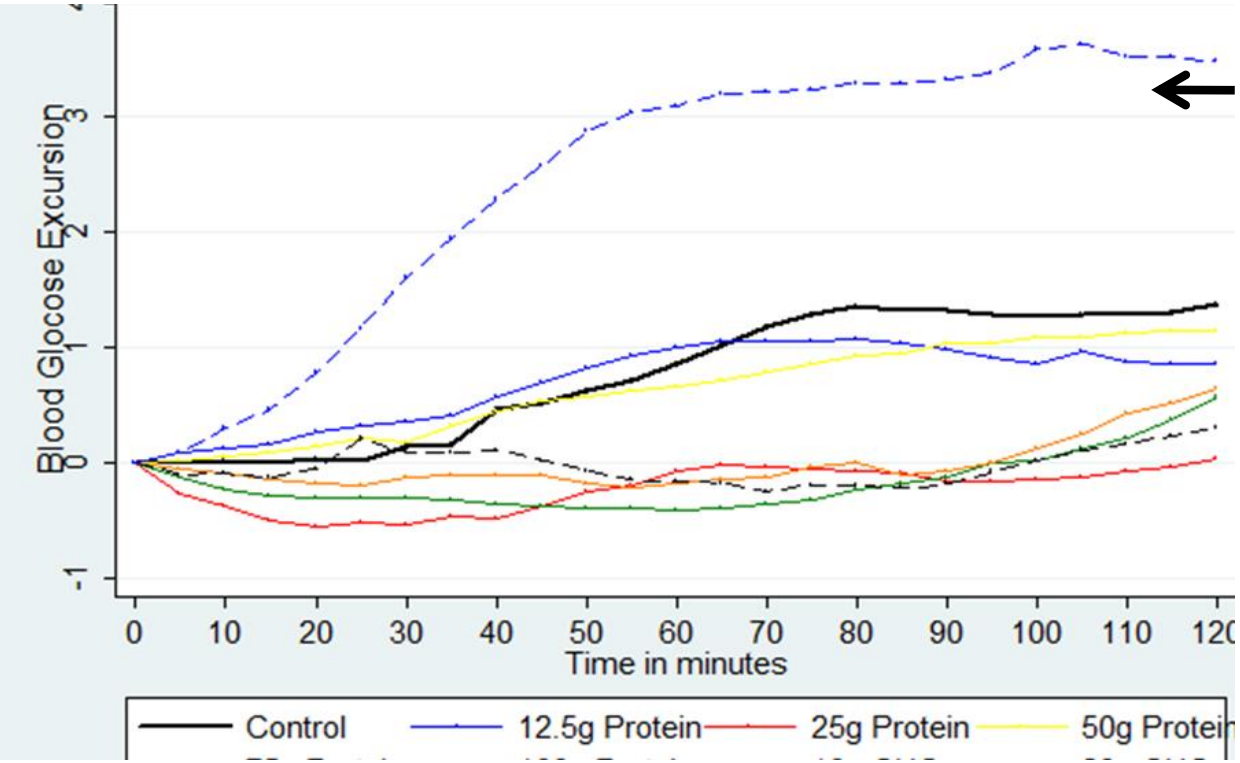
Paterson et al, Diabetic Medicine 2017



↑ 75g Pro
I
I
I 50g
I 25g
I 12.5g
I CHO ONLY

Impact of protein only meals on postprandial glucose

Paterson et al, Diabetes Med 2015



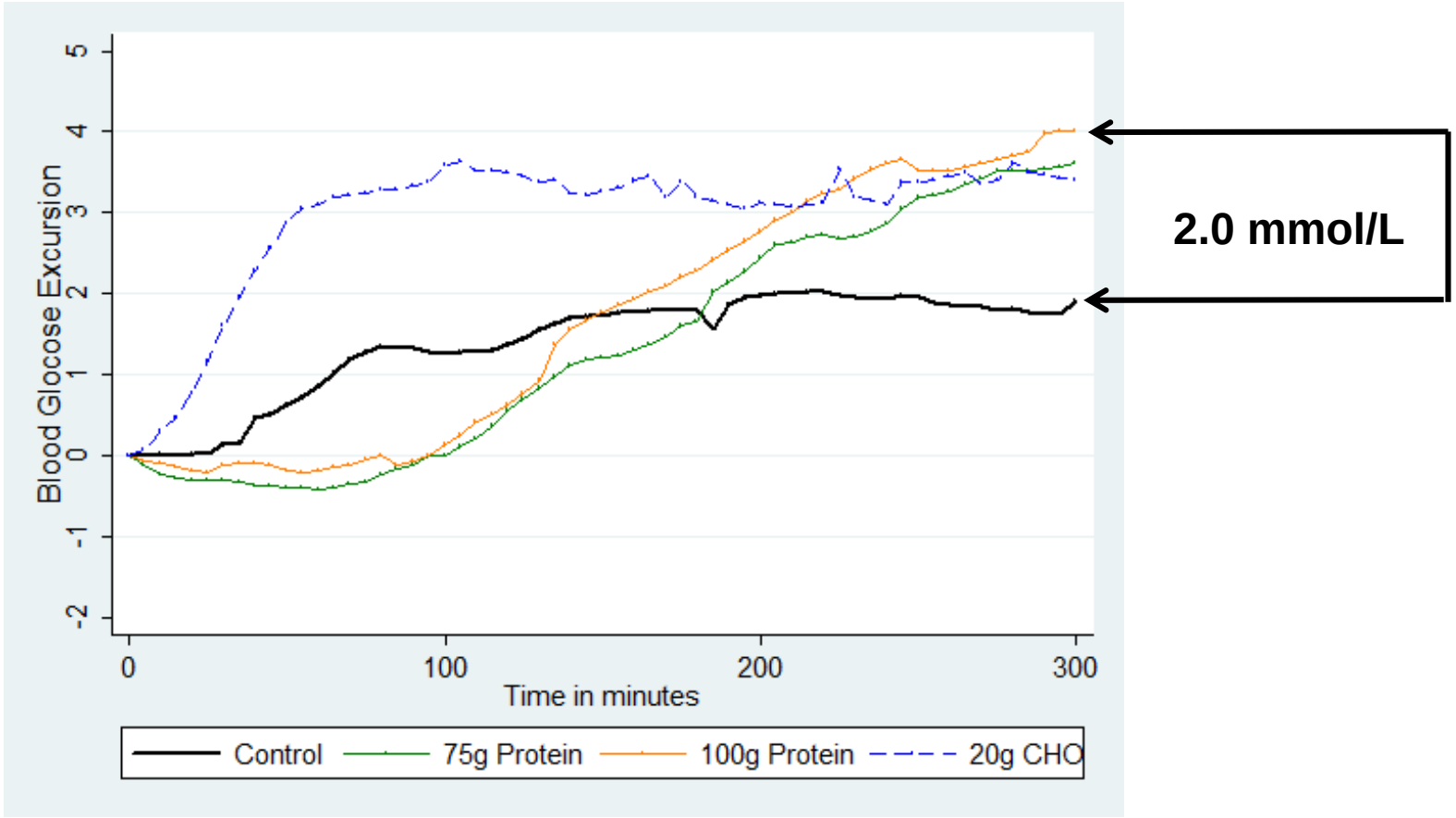
20g CHO ONLY

Protein ONLY

STUDY AIM: To examine the effects of protein alone (independent of Carbohydrate and fat) on postprandial glycaemia in children and adults with T1D using intensive insulin therapy

Impact of protein only meals on postprandial glucose

Paterson et al, Diabetes Med 2015



Summary: Impact of dietary protein

- ≥ 30-40g of protein in meal or ≥ 50g protein alone causes delayed BGL rise
- Protein added to a meal dampens the early glycaemic rise
- ≥ 30-40g protein added to a CHO containing meal may help prevent late post-meal hypoglycaemia

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Summary: Impact of dietary fat

- Fat reduces early postprandial glucose excursions (Lodefalk et al 2008)
- Fat increases delayed hyperglycaemia (Wolpert et al 2012)
- Type of fat may have different impacts (Bozzetto et al 2016, 2018)



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IMPACT OF DIETARY FAT

EVIDENCE

Amount and Type of Dietary Fat, Postprandial Glycemia, and Insulin Requirements in Type 1 Diabetes: A Randomized Within-Subject Trial

Kirstine J. Bell,[1] Chantelle Z. Fio,[1] Stephen Twigg,[1,2] Sally-Anne Duke,[3] Gregory Fulcher,[3] Kylie Alexander,[3] Margaret McGill,[2] Jencia Wong,[2] Jennie Brand-Miller,[1] and Garry M. Steil[4,5]

20g, 40g, 60g fat

Diabetes Care 2020;43:59–66 | https://doi.org/10.2337/dc19-0687

Impact of macronutrient content of meals on postprandial glucose control in the context of closed-loop insulin delivery: A randomized cross-over study

Véronique Gingras PhD[1,2] | Lisa Bonato MD[1] | Virginie Messier MSc[1] | Amélie Roy-Fleming RD[1,2] | Mohamed R. Smaoui PhD[1,2] | Martin Ladouceur PhD[3] | Rémi Rabasa-Lhoret MD[1,2,4,5]

35g fat, 35g protein

Consider additional insulin for food ≥30g Fat and ≥40g Protein.

Smart *et al* 2013, Paterson *et al* 2017





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OZDAFNE Dose Adjustment For Normal Eating in Australia

However individualise - may be lower amounts for different diet patterns, ages and sensitivities

Smith et al 2020, Bell et al 2020

Is additional insulin needed for Protein?

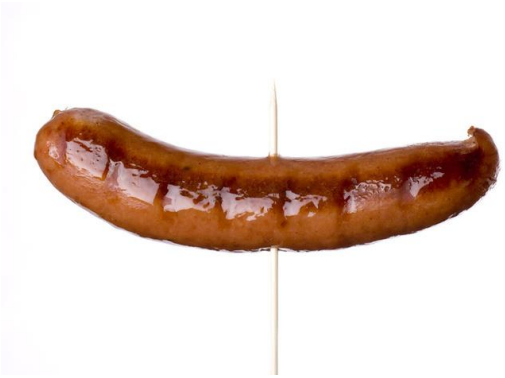
40g mixed nuts

260g T bone Steak

8g Protein

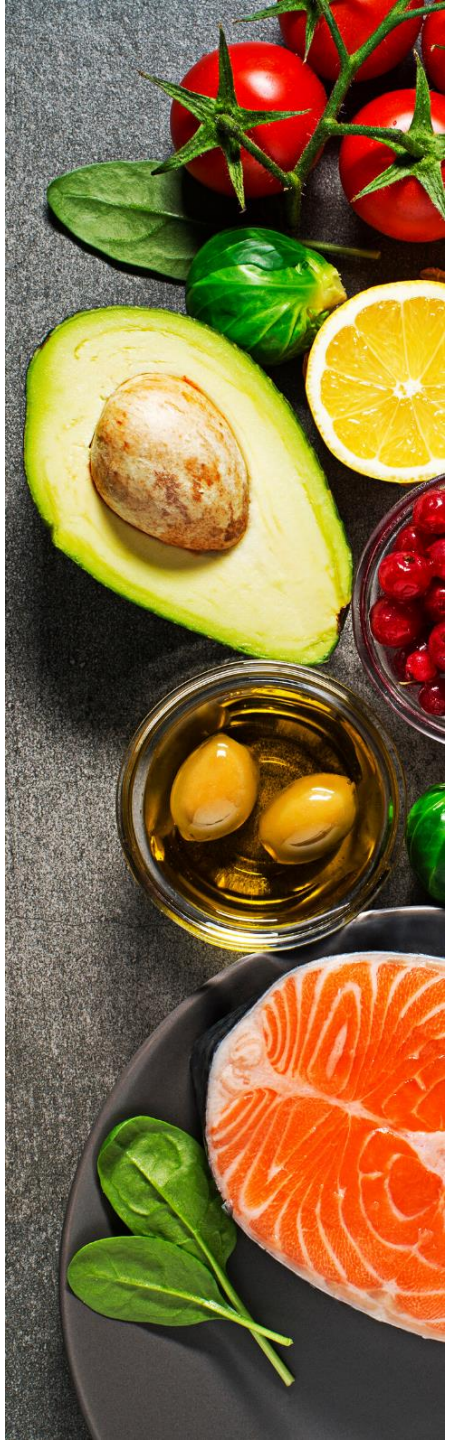
75g Protein

Is additional insulin needed for Fat?



One sausage

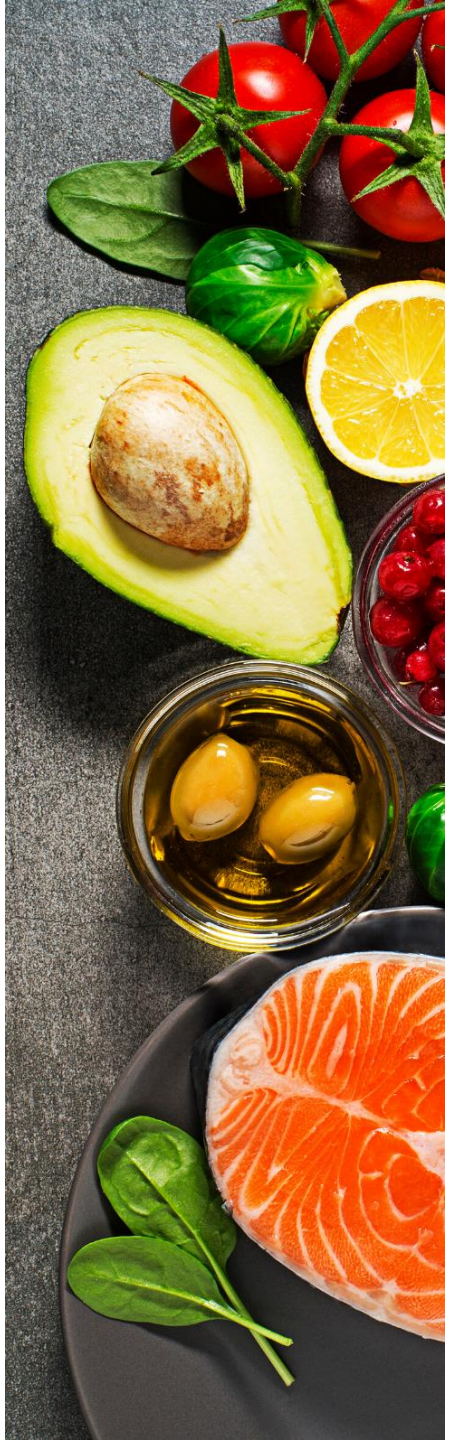
Two sausages



Is additional insulin needed for Fat?

One sausage

Two sausages



Dietary resources

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<15 g PROTEIN/ SERVE		15- < 30g PROTEIN/ SERVE	
<5g	5- <15g	15- < 30g	30-
Serve fruit/vegetables **<1g protein**	¼ cup nuts / Tbs peanut butter **6g protein**	6 chicken nuggets **15g protein**	100g coc **30g p**
Oil/margarine/sauce/dip **<1g protein**	2-3 slices deli meat **6g protein**	2 chicken tenders **15g protein**	125-150g cook fillet) **30g**
1 medium scoop ice cream - **1g protein**	1 egg, **6g protein**	95g tin fish **15g protein**	400g serve lasa **40g p**
100g cooked Rice/pasta **2g protein**	½ cup baked beans/legumes/lentils **7g protein**	Ham and cheese sandwich **20g protein**	3-4 slices meat pizza **35g protein**
1 slice bread **2g protein**	150g tub yoghurt/1 cup milk / 2 slices cheese **9g protein**	½ cup (70g) cooked mince/ 1Burger Patty, **20g protein**	Takeaway burger **35g protein**
Unfortified cereal **3g protein/serve**	1 sausage **10g protein**	2 egg omelette with cheese **20g protein**	200g cooked chicken breast **60g protein**
		2 taco/wrap with meat and cheese **24g protein**	
		1 lamb chop **25g protein**	

<10g FAT / SERVE		10- <20g FAT/ SERVE	≥20g FAT / SERVE	
<5g	5- <10g	10- <20g	20- <30g	30-40g
Serve fruit/vegetables **0g fat**	1 large egg **5 g fat**	1 cup meat + vegetable stir fry **11g fat**	2 tacos / regular burrito **20g**	Slice/ individual quiche **33g fat**
½ cup Lentils / legumes **<1g fat**	1Tbs Nutella **6g fat**	medium chicken schnitzel or lean burger patty **14g fat**	300g Lasagne **20g fat**	Large meat and cheese burger **30g fat**
1 serve grain foods **<2g fat**	Meat and salad sandwich/wrap 1 sushi roll **7g fat**	1.5 Tbs peanut butter / ¼ cup unroasted nuts **15g fat**	150g bucket hot chips **20g fat**	~ 300g creamy based pasta or curry meal **30g fat**
Tub low fat yoghurt / 1 cup light milk **2g fat**	Muesli bar / 2 biscuits **7g fat**	100g cooked salmon **15g fat**	1 medium lamb chop, untrimmed **25g fat**	3 slices pizza, classic crust **30g fat**
1tsp margarine/ oil **3g fat**	¼ medium avocado **8g fat**	2 cocktail frankfurts / 1 sausage **16g fat**	Single serve pie / sausage roll **25g fat**	Caesar salad (bacon, egg, creamy dressing) **35g fat**
1 medium scoop ice cream **5g fat**	2 slices low fat cheese / 1 cup full cream milk **9g fat**	2 egg omelette with cheese **17g fat**	1 slice cake / medium muffin **28g fat**	Fish & Chips **40g fat**

Tip:

- **Optimise ICR and basal to determine impact of fat and protein**
- **Teach identification of high protein and fat meals that may cause delayed rise in BGLs**

Insulin dosing strategies for fat and protein

- How much additional insulin?
- How and when should this be delivered?

Pump Therapy:
Fat and Protein Dosing

Comparison of insulin dosing methods for fat and protein in people using insulin pumps

Lopez *et al*, Diabetic Medicine, 2018

PE reduced the time spent in postprandial hyperglycaemia at the expense of an increase in the incidence of hypoglycaemia (BGL < 3.9 mmol/L)

Meal	Algorithm	% time in target	Hypo rate %
HF	CC	58.3	6.7
	PE	64.4 *	44.8 **
HP	CC	54.4	3.9
	PE	74.9 *	21.7 **

n= 29

How much additional insulin?

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+6% (20, 40g fat) and +20% (60g fat)

Diabetes Care 2020;43:59–66 | https://doi.org/10.2337/dc19-0687

Impact of macronutrient content of meals on postprandial glucose control in the context of closed-loop insulin delivery: A randomized cross-over study

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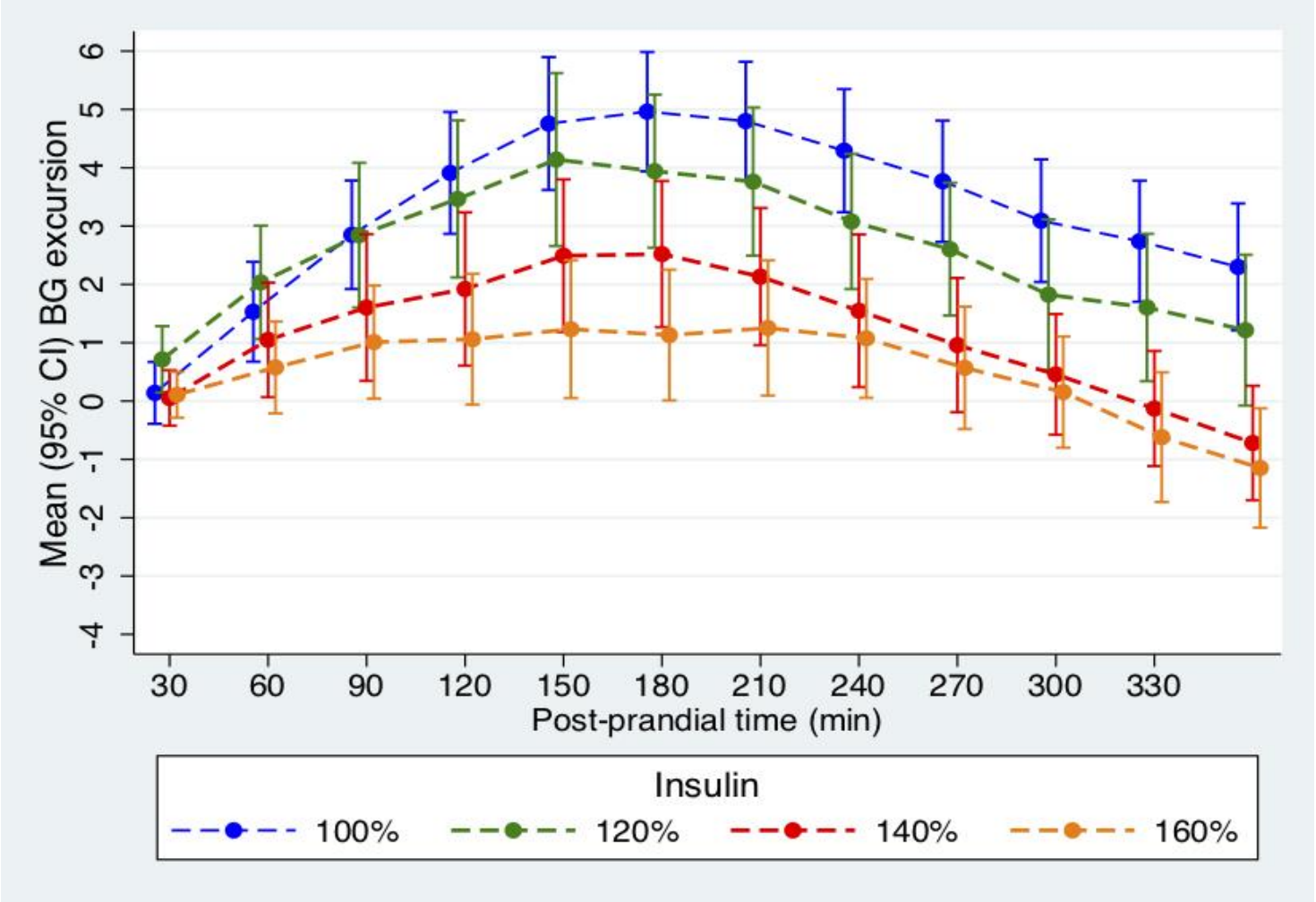
+39% (35g fat, 35g protein)

How much additional insulin for high fat and protein in pump therapy?

Additional 40% of the mealtime insulin dose for high fat , high protein meal in bolus over 3hrs.

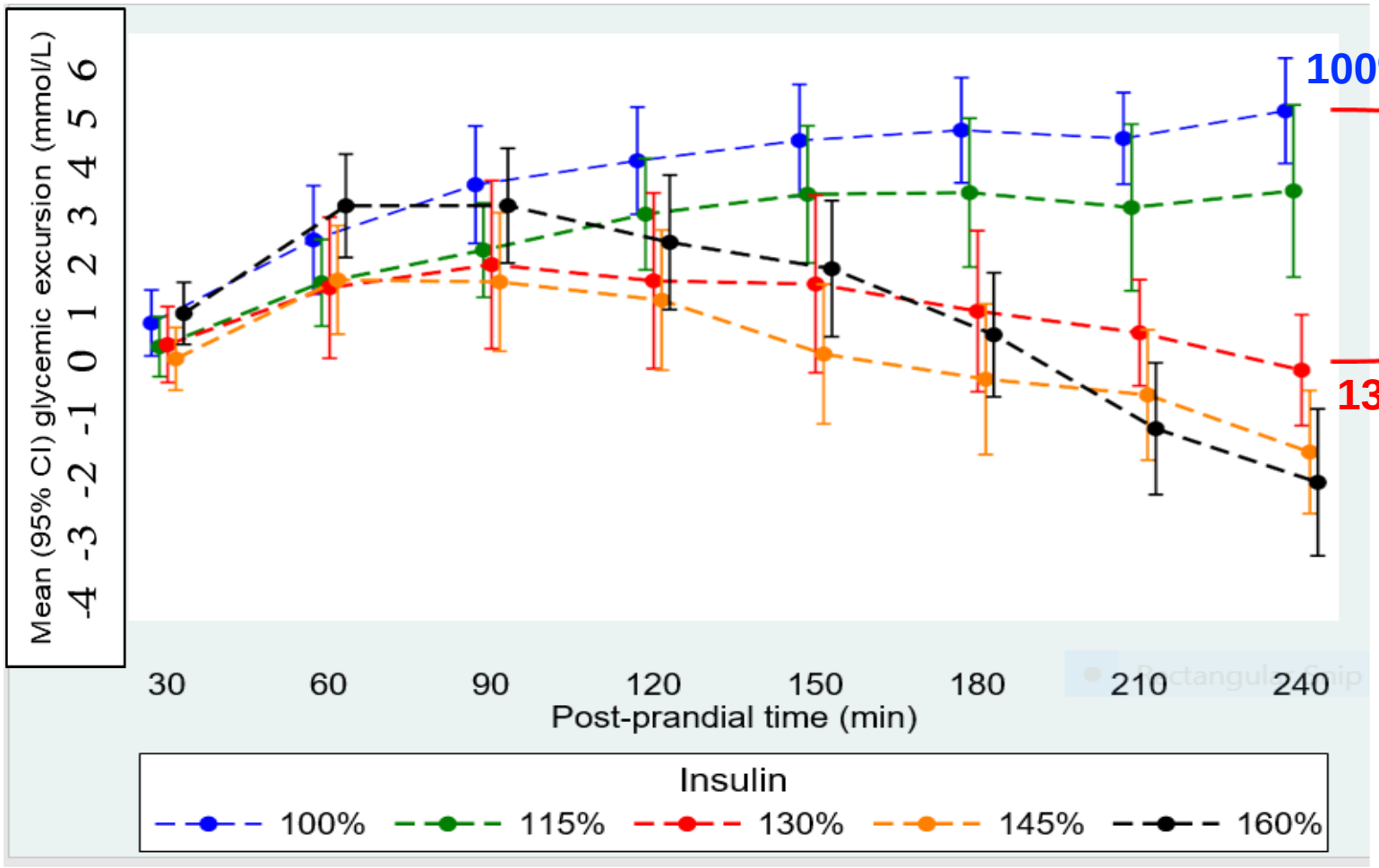
Increase or decrease dose based on the individual glucose response.

Smith T *et al*, ADA 2020



How much additional insulin for protein in pump therapy?

+30% to carbohydrate dose for high protein (50g) meal over 3 hours



100% ICR

4.6 mmol/L
P<0.001

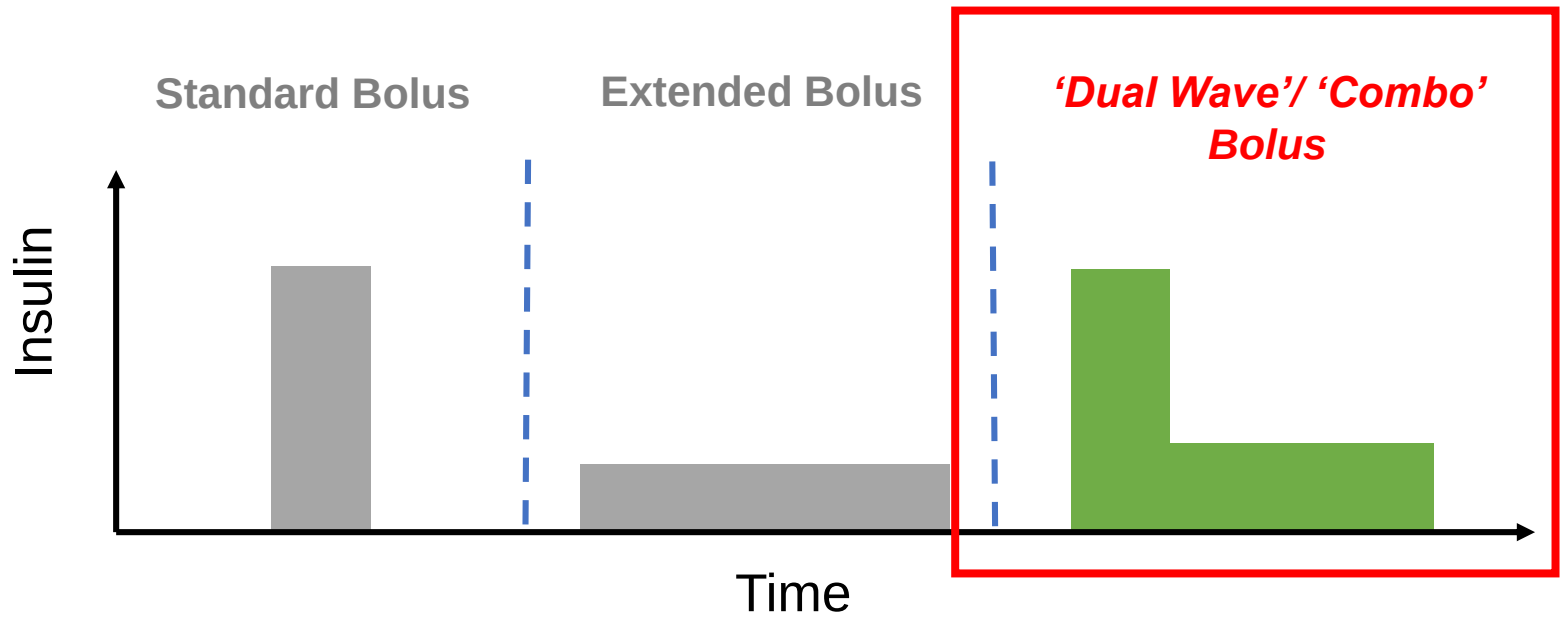
130% ICR

Paterson M et al. Diabet Med 2020

Pattern of insulin delivery for high fat, high protein meals

Lopez *et al*, *Diabetic Medicine, 2017*

60%: 40%



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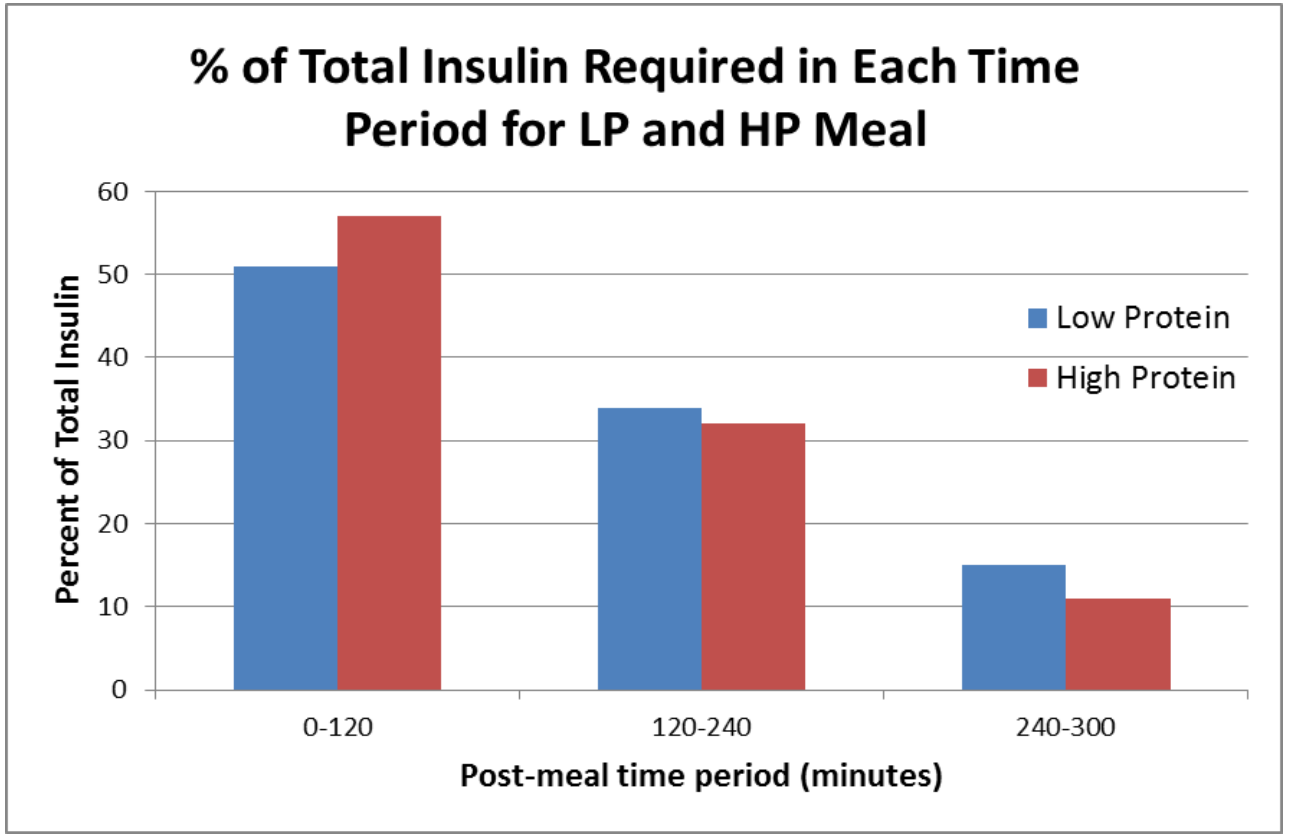
Pattern of delivery for high protein meals

More than half of the IV insulin was needed in the first two hours



Evans *et al, Diabetic Medicine 2019*

Pattern of delivery for high fat meals

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Diabetes Care 2020;43:59–66 | https://doi.org/10.2337/dc19-0687

	Mean carb dose increase (% ICR)	Split	Duration (min)
+20g fat	+6	78:22	73
+40g fat	+6	67:33	75
+60g fat	+21	59:41	105

Summary: Insulin dosing and delivery in pump therapy

Lopez et al 2017, Paterson et al 2019, Smith et al 2018, Bell et al 2020

- Add +20-40% to carb ratio
- Use combination type bolus:
  - 60-70% of total dose upfront
  - Deliver over 2-3 hours

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Dosing for fat and protein in clinical practice

Carbohydrate in the meal (g)	Add 30% to Carb Dose		
	Fat and Protein supplement (g)	Total grams to bolus	60:40 Split Bolus (g)
20	5	25	15 : 10
30	10	40	25: 15
40	10	50	30 : 20
50	15	65	40 : 25
60	20	80	50 : 30

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What Bolus strategy would you use for this meal?

Carb	60g
Fat	40g
Protein	30g

What Bolus strategy would you use for this meal?

Carb	60g
Fat	40g
Protein	30g

- Add 20% more insulin: 60g carb + 12g Protein/Fat supplement (20%) = 72g carb
- Give 60% of dose before and 40% over 2-3 hours
- Give 45g before and 30g carb over 2-3 hours

Insulin dosing- high protein, high fat

MANUAL MODE VS AUTO MODE

Manual Mode

Meal: 40g protein, 30g fat and carbohydrate

Add 20% to Carb dose and increase as needed to 40%

Split total dose 60:40% in Dual wave over 3 hours

Smith et al ISPAD 2019

Auto Mode

Meal: 40g protein, 30g fat and 50g carbohydrate

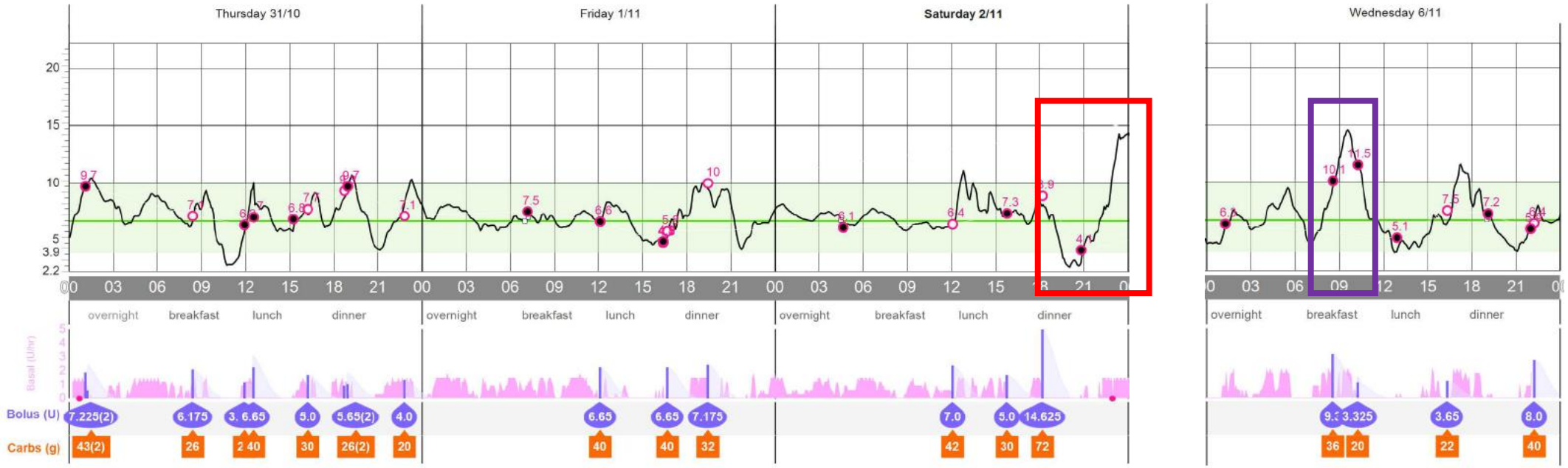
Add 20% to Carb dose and increase as needed to 30%

Give 60% of dose before and 40% at 1 hour

For example: 50g carb + 15g Protein/Fat supplement (30%) = 65g carb

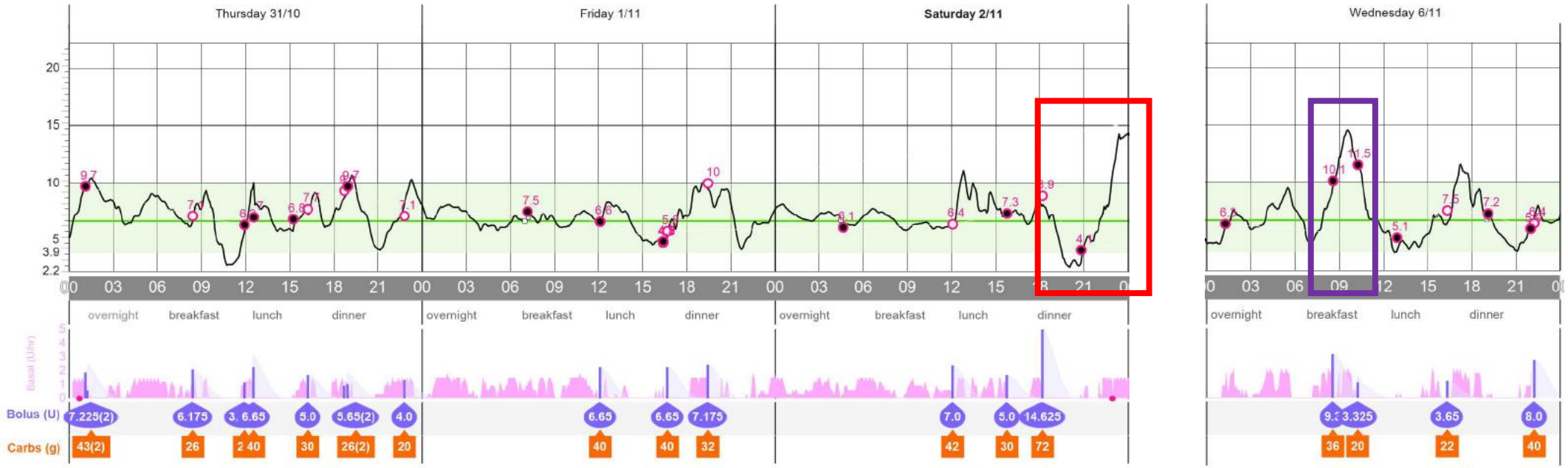
Food Behaviours on HCL matter

Hypo over-treatment **Postprandial dosing**

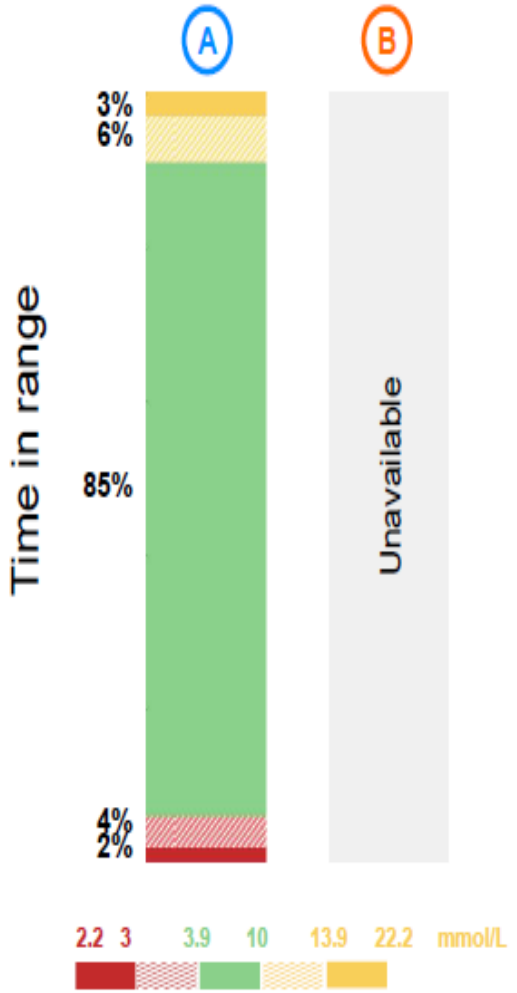


Food Behaviours on HCL matter

10-15g carb treatment **Dose 15 mins before**



Achieving targets: Bolus 15 mins before meals, limit grazing



Auto Mode Exits	A	B
No Calibration	0	--
High SG Auto Mode Exit	• 1	--
Auto Mode max delivery	0	--
Auto Mode min delivery	0	--
BG required for Auto Mode	• 1	--
Sensor Algorithm Underread	0	--
Sensor Updating	0	--
No SG values	• 1	--
Sensor Expired	0	--
Auto Mode disabled by user	+ • • • • • 10	--
Alarms	• • 2	--
Pump Suspend by user	0	--
Auto Mode Warm Up	0	--
Unidentified	0	--

Statistics	A	B
Auto Mode (per week)	91% (6d 09h)	--
Manual Mode (per week)	9% (15h)	--
Sensor Wear (per week)	93% (6d 13h)	--
Average SG ± SD	7.1 ± 2.5 mmol/L	--
Estimated A1C	6.1%	--
Average BG	6.8 ± 2.4 mmol/L	--
BG / Calibration (per day)	6.5 / 6.1	--
Total daily dose (per day)	53 units	--
Bolus amount (per day)	40U (75%)	--
Auto Basal / Basal amount (per day)	13U (25%)	--
Set Change	Never	--
Reservoir Change	Every 2.2 days	--
Meal (per day)	6.8	--
Carbs entered (per day)	190 ± 47 g	--
Active Insulin time	2:00 hrs	--

Tip: Pump therapy : High fat, high protein meals

- **Start with additional 20% ICR and grade up in 10% increments to 40% more**
- **Give dose as extended bolus (split 60:40) over 2-3 hrs**

MDI therapy: Fat and Protein Dosing

Insulin strategies for fat and protein meals in MDI therapy

Two studies:

- Campbell et al, 2016 Diabetes Care (n=10)
  - Secondary bolus injection +30% at 3 hours
- Jablonska et al, 2018 Diabetes Ther. (n=25)
  - No difference between regular and fast acting

MDI – high fat/high protein dose

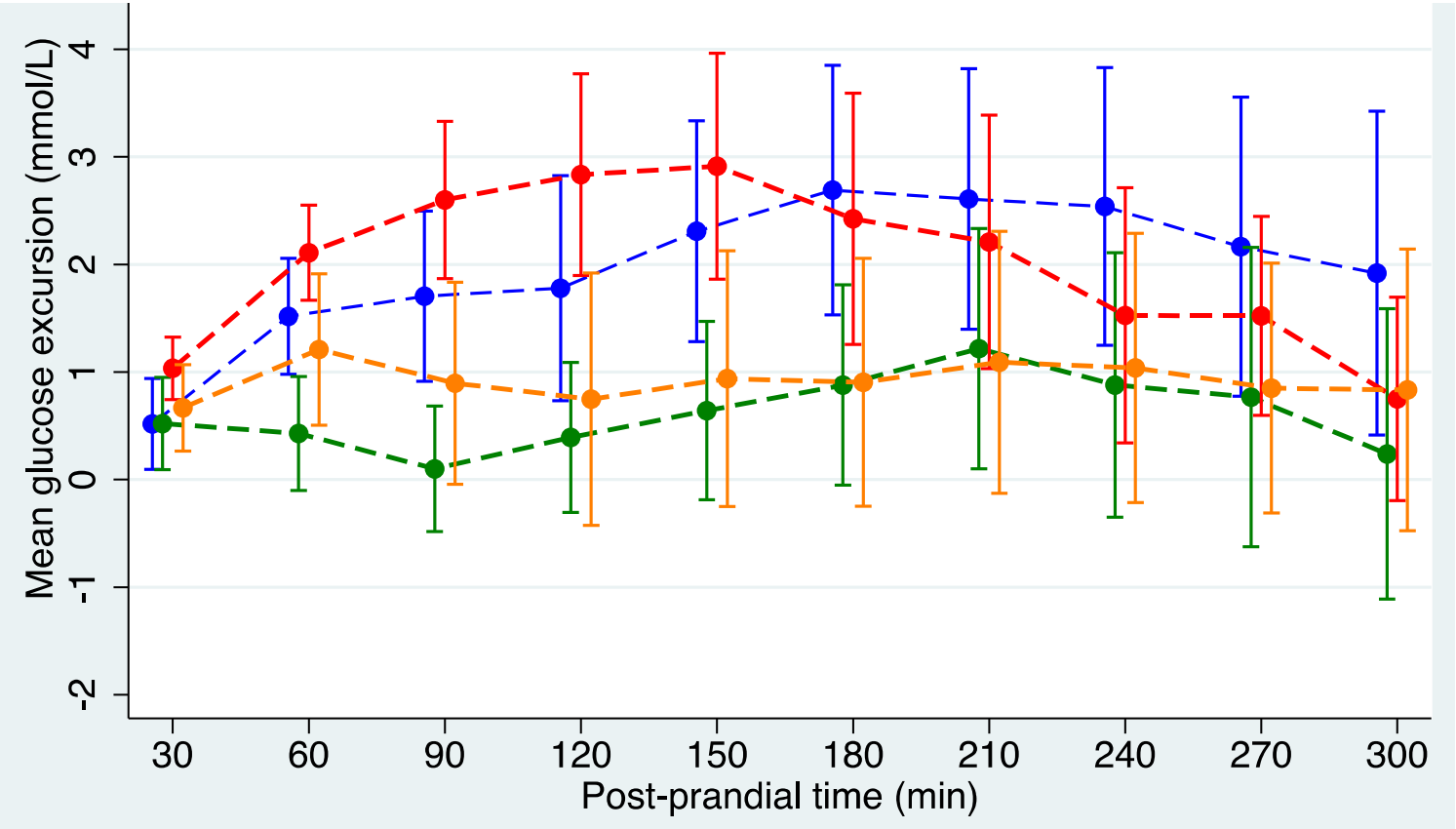
- Tenele Smith,  JHCH, best oral at ISPAD 2020
- N = 24, 8-40 yrs, MDI Meal: 30g carb, 40g fat, 50g protein

- Bolus conditions:
  1. 100% dose, 15 min pre- meal, aspart insulin
  2. 125% dose, 15 min pre meal, aspart insulin
  3. 125% dose,15 min premeal, regular insulin
  4. 125% dose: 100% pre meal, 25% at 1 hr, aspart insulin

Smith, T., Smart, C., Howley, P., King, B., (2020). Best Oral presentation ISPAD October 2020

MDI – high fat/high protein dose

Giving 125% of the carb dose preprandially (15 min) using aspart insulin significantly improved postprandial glycaemia without hypoglycaemia.



100% Aspart (control)

125% Regular
100:25% Aspart
125% Aspart

*p< 0.05, ** p< 0.01

Smith, T., Smart, C., Howley, P., King, B., (2020). Best Oral presentation ISPAD October 2020

Tip: **MDI : High fat, high protein meals**

- **Start with additional 10%- 25% ICR and give all upfront.**
- **If hypo at 1-2 hours, split dose with additional insulin 60 min post- meal.**
- **Splitting the dose or using regular insulin does not usually confer advantage**

Insulin dosing- protein only

PUMP THERAPY AND MDI

Paterson et al 2017, Paterson et al 2019

For meals containing protein only

- Give equivalent of 10-15 grams of carbohydrate for approx. 50g protein. (1g CHO=5 g protein)
- Increase on an individual basis or start at lower protein threshold as indicated by food impact

What bolus strategy would you use for this meal?

Carb	0g
Fat	30g
Protein	35g

What bolus strategy would you use for this meal?

Carb	0g
Fat	30g
Protein	35g

- Give equivalent of 15 grams carbohydrate
- Give immediately before eating
- Increase on an individual basis

Structured meals

Improved BGLs during COVID lockdown:

- *Meal routines*
- *Family based food*

Blood Glucose Control During Lockdown for COVID-19: CGM Metrics in Italian Adults With Type 1 Diabetes

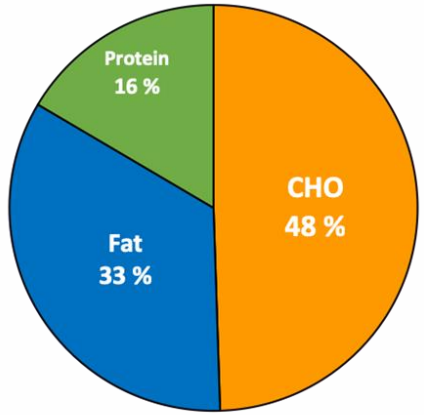
Diabetes Care 2020;43:e88–e89 | https://doi.org/10.2337/dc20-1127

Brunella Capaldo, Giovanni Annuzzi, Annalisa Creanza, Clemente Giglio, Raffaele De Angelis, Roberta Lupoli, Maria Masulli, Gabriele Riccardi, Angela Albarosa Rivellese, and Lutgarda Bozzetto

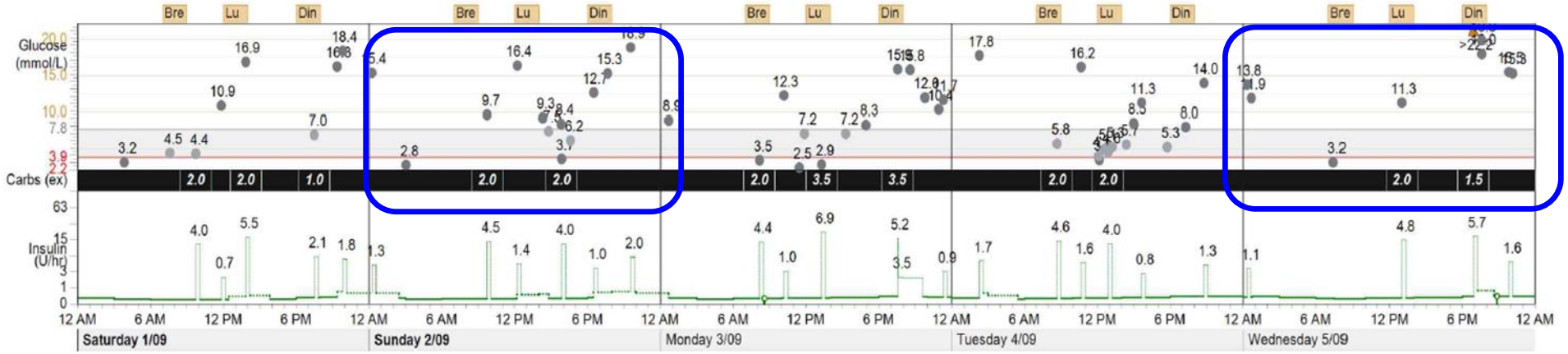
Positive association: HbA1c and pattern of eating

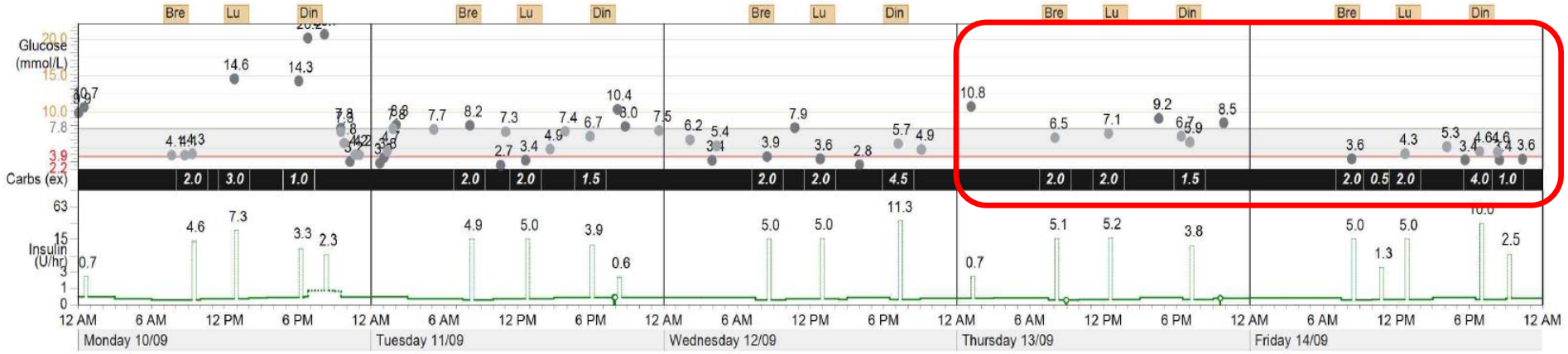
Seckold R et al BMJ Open 2019

Characteristics of children (<6 yrs)	
	Mean ± SD
Total Number	22
Age	4.9 ± 1.3y
HbA1c	6.4 ± 0.9%



Post and pre-prandial dosing without changing food intake





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Common meal behaviours in people achieving target BGLs

- Frequent BG monitoring with correction at meals of above target BGLs
- Multiple (≥4) doses for food / day with pre-prandial insulin
- Mealtime structure
- Consider impact of all macronutrients in insulin dose and delivery
- Understanding of individual BG responses to foods

Seckold et al Diabet Med 2018

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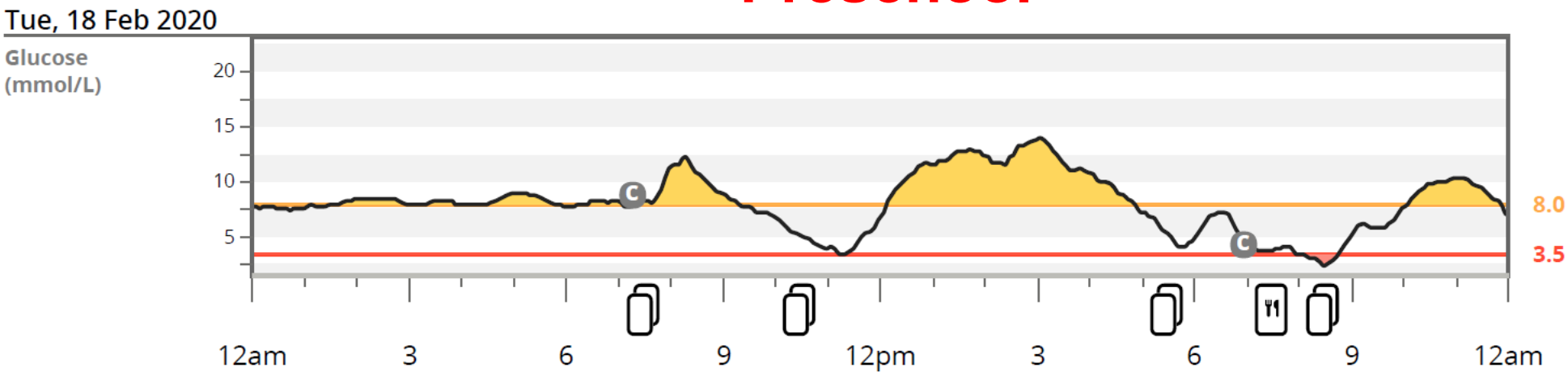
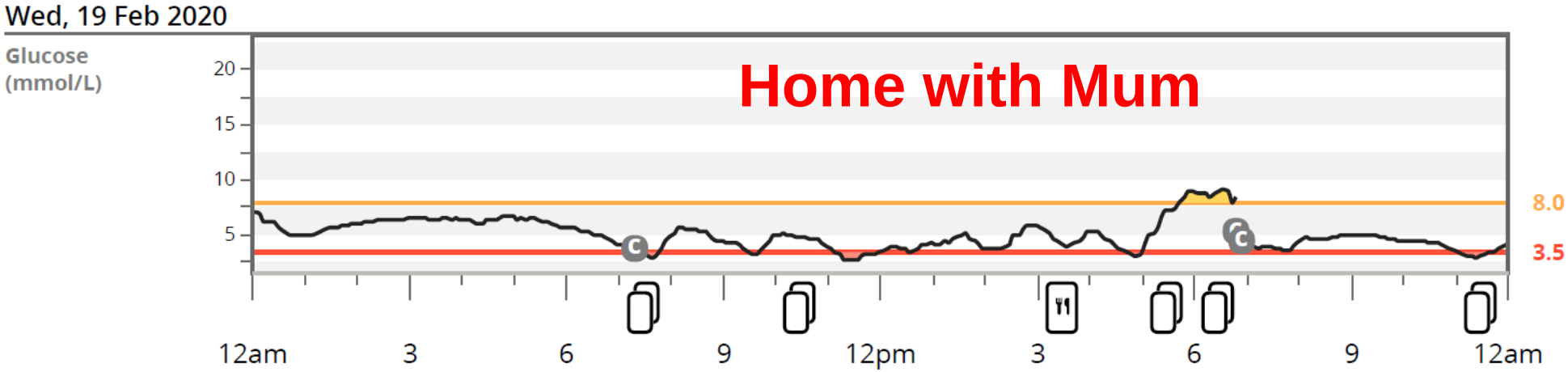
Tip: **Dietary Behaviours**

- **Meal-time routines**
- **Pre-prandial insulin**
- **Insulin for all snacks >10-15g Carb**

Carbohydrate inaccuracies and postprandial insulin

Preschool





Home with Mum

Key Takeaways: Carb, Fat and Protein Counting

Do's	Dont's
Bolus 15 min before food	Bolus after food
Treat hypo's with 10-15g of carb	Overtreat hypo's
Step 1 Check carb counting accuracy	Snack continually and skip meals
Step 2 Optimize ICR and basal	Give message "All carbs are equal"
Step 3 Additional insulin for high fat and high protein meals	An absolute dietary focus can detract from whole person management approach
Work with individual on dietary preferences	Additional insulin for fat and protein should be calculated as a % of the meal insulin only, do not include correction insulin
If habitual dietary intake changes, ICR needs to be reviewed	Forget to review individual impact of dose increases at 3 and 6 hours

Thank you

- The children and young adults with type 1 diabetes and their families
- Research and clinical teams (John Hunter Children's Hospital)
- The Australian Artificial Pancreas Program (University of Newcastle)
- Research Team (Perth Childrens Hospital, Australia)