SETTING THE STAGE AND PEAK PROGRAM OVERVIEW

IAN GALLEN

JDRF PEAK
T1D Performance in Exercise and Knowledge

Disclosures Ian Gallen

Geen (potentiële) belangenverstrengeling	
Voor bijeenkomst mogelijk relevante relaties	**Bedrijfsnamen**
•Geen	• geen • • • •

CURRENT ENVIRONMENT AND LITERATURE

Information on Management of Exercise in People with T1D

- Under-represented in literature
  - Limited scientific publications with most being clinical trials or studies looking at performance/glucose response
- Significant web coverage
  - Most sites geared at T1D athletes and their families
  - No sites specifically target education of HCPs
- No well-established or official guidelines or recommendations
- Unmet need

JDRF PEAK T1D Performance in Exercise and Knowledge

JDRF PEAK Program Overview

- T1D Performance in Exercise and Knowledge (PEAK)
- Audience: Patients, their families, and HCPs
- Aims:
  - To increase education and provide tools on the management of physical activity for individuals with T1D
  - To support safe, informed exercise within the T1D community
- Format:
  - Core educational sessions and tools to illustrate the normal and abnormal metabolic responses to different forms of exercise and glycemic management strategies
  - Specialized electives on topics ranging from pumps and technologies to child and adolescent care
  - Curriculum geared to HCPs (1-day programme)
  - Curriculum geared to patients with T1D and their families/caregivers (1/2 day program)

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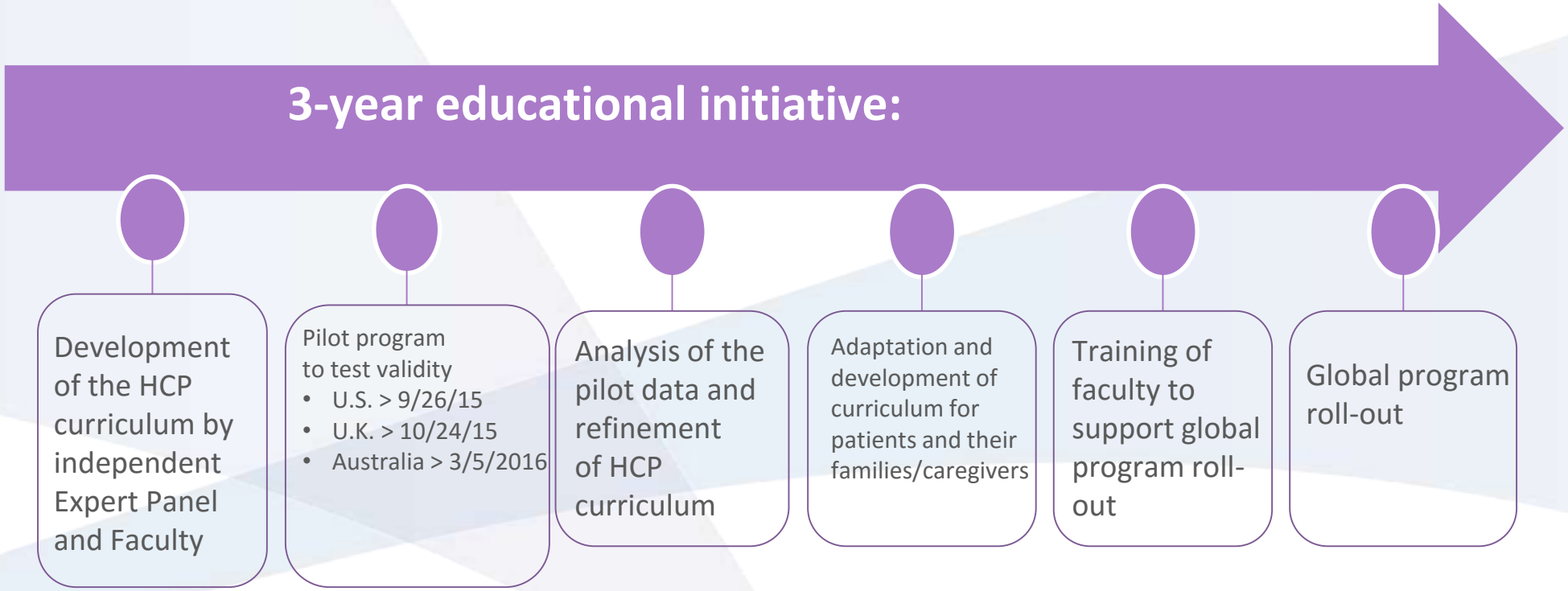
Strategy and Program Implementation



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INTRO TO EXERCISE MANAGEMENT & T1D

Recommendations

Benefits

Challenges

Management

RESENTING SPONSOR

ovo nordisk

Exercise Recommendations

- **Adults: 150 minutes/week** of moderate- to-vigorous physical activity (brisk walking or greater), with no more than 2 days off in a row + strength training 2-3 X/ week

- **Youth: 60 minutes/day** of moderate-to- vigorous physical activity (420 min/week), including vigorous-intensity activities 3+ days/week and strength building activities (for muscle and bone) 3+ days/week

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Benefits of Exercise in Diabetes

- Weight management, increased lean body mass
- Reduced cardiovascular risk factors
  - Lower BP
  - Lower unfavorable & higher favorable lipids
- Improved insulin sensitivity
- Psychological benefits
  - Improved sense of well-being
  - Improved self-esteem

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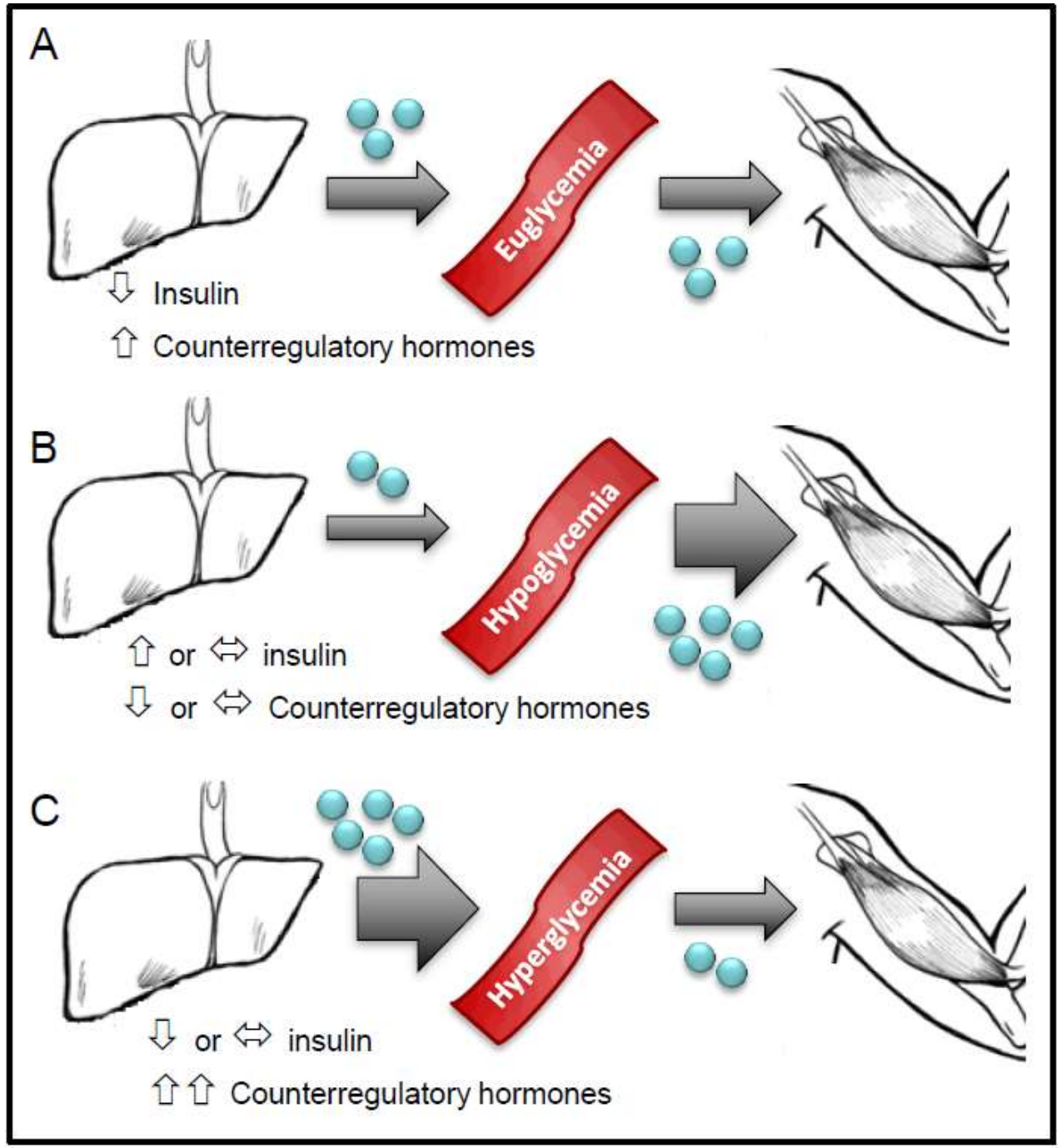
Challenges of Exercise

- Injury
- Little impact on overall glycemic management(HbA1c)
- Hypoglycemia
  - Immediate – during or right after exercise
  - Delayed – the “lag effect” of exercise
    - Can occur 6-15 hours after exercise (on average 7-11 hours after activity – usually overnight)
- Hyperglycemia

Exercise and Hypoglycemia with Insulin Rx

- Absence of physiological decrease in insulin secretion with exercise
- Increase in absorption of insulin from subcutaneous area
- Increase in rate of glucose transport into muscle
- Blunting of counter-regulatory hormone responses in patients with T1D (esp. with sleep)
- Diminished hepatic glucose production (elevated insulin/glucagon ratio in portal vein)



Chu L, Hamilton J, Riddell MC. *Phys Sportsmed.* 2011;39(2):64-77

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Risk for Nocturnal Hypoglycemia

During sleep and after exercise, children with type 1 diabetes have:

1. Increased glucose requirements
   - Increased insulin sensitivity
   - Glycogen restoration
2. Impaired counter regulation
3. Excessive circulating insulin

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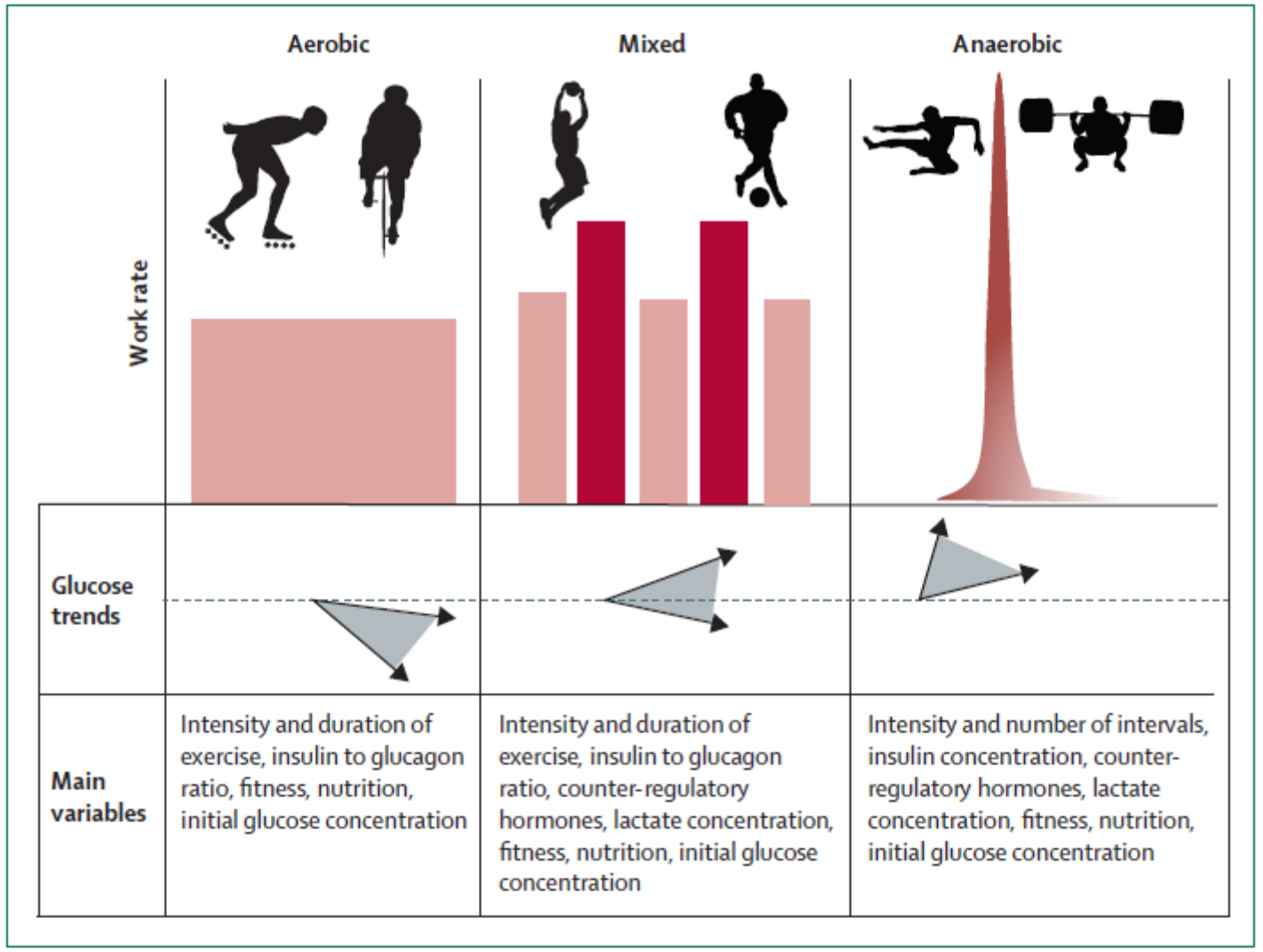
Exercise Management

- Understand factors affecting response to exercise
  - Duration and intensity
    - Moderate intensity may lower BGs more than maximum intensity
  - Type of activity-anaerobic vs aerobic
  - Metabolic control
  - BG level at time of exercise
  - Timing and type of insulin
  - Timing and type of food
  - Absorption of insulin, site of injection
  - Conditioning
  - Stress / competition
  - Timing of activity

BG Effects of Different Types of Exercise



Riddell et al. Exercise Management in T1D: A Consensus Statement. Lancet Diab Endo 2017

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PHYSIOLOGY

PER WINTERDIJK

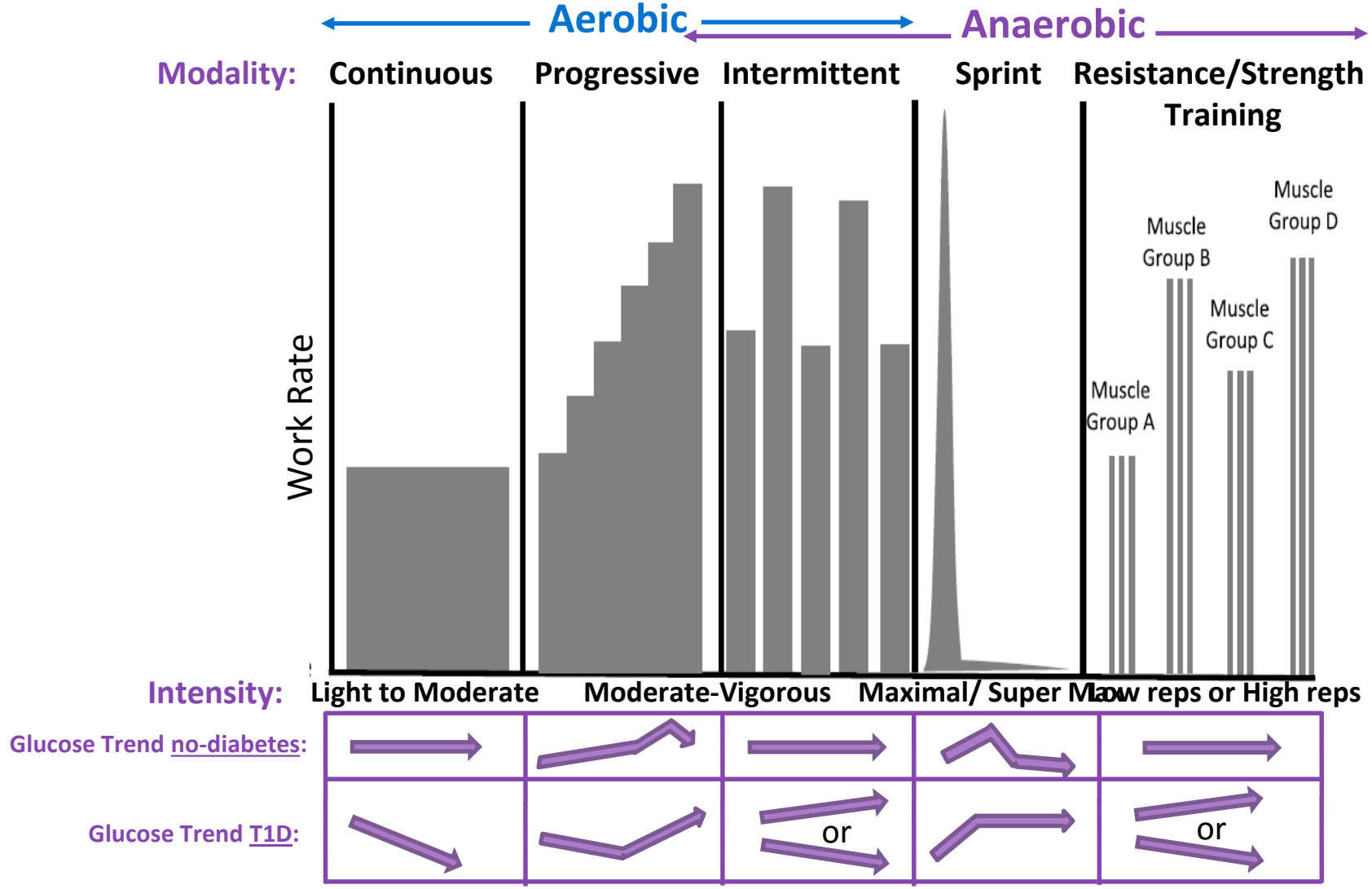
Disclosures Per Winterdijk

Geen (potentiële) belangenverstrengeling	
Voor bijeenkomst mogelijk relevante relaties	**Bedrijfsnamen**
•Geen	• • • • •

Session Objectives

- Using two clinical case studies, this session will:
  - Demonstrate the hormonal and metabolic responses to various types of exercise
  - Illustrate the mechanisms for the maintenance of euglycemia, hypoglycemia and hyperglycemia during and after exercise

Exercise Comes in Several Different Forms, Each with Different Effects on Glucose Levels



Adapted from: Riddell, MC, *et al*. *Journal of Diabetes Science and Technologies* 2016: DOI: 10.1177/1932296815609370

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Sally

Age	38-year-old female
Duration of Diabetes	7 years
BMI	28 kg/m^2
History	Uncomplicated diabetes, MDI, HbA1c 7.6% (60 mmol/mol), hypoglycemia awareness
Concerns/situation	• Adopted a new exercise program to lose weight, manage blood glucose levels and improve fitness (aerobics class 2x per week, brisk walking) • Has been experiencing hypo events during and sometimes after exercise

The need to eat extra carbs feels counter-productive to Sally, who is hoping exercise will help with weight loss
What approaches can she use to exercise safely without hypoglycemia and achieve her goal?

Exercise Management

- **Consider insulin (on board):**

LESS INSULIN

VS

MORE CARBS

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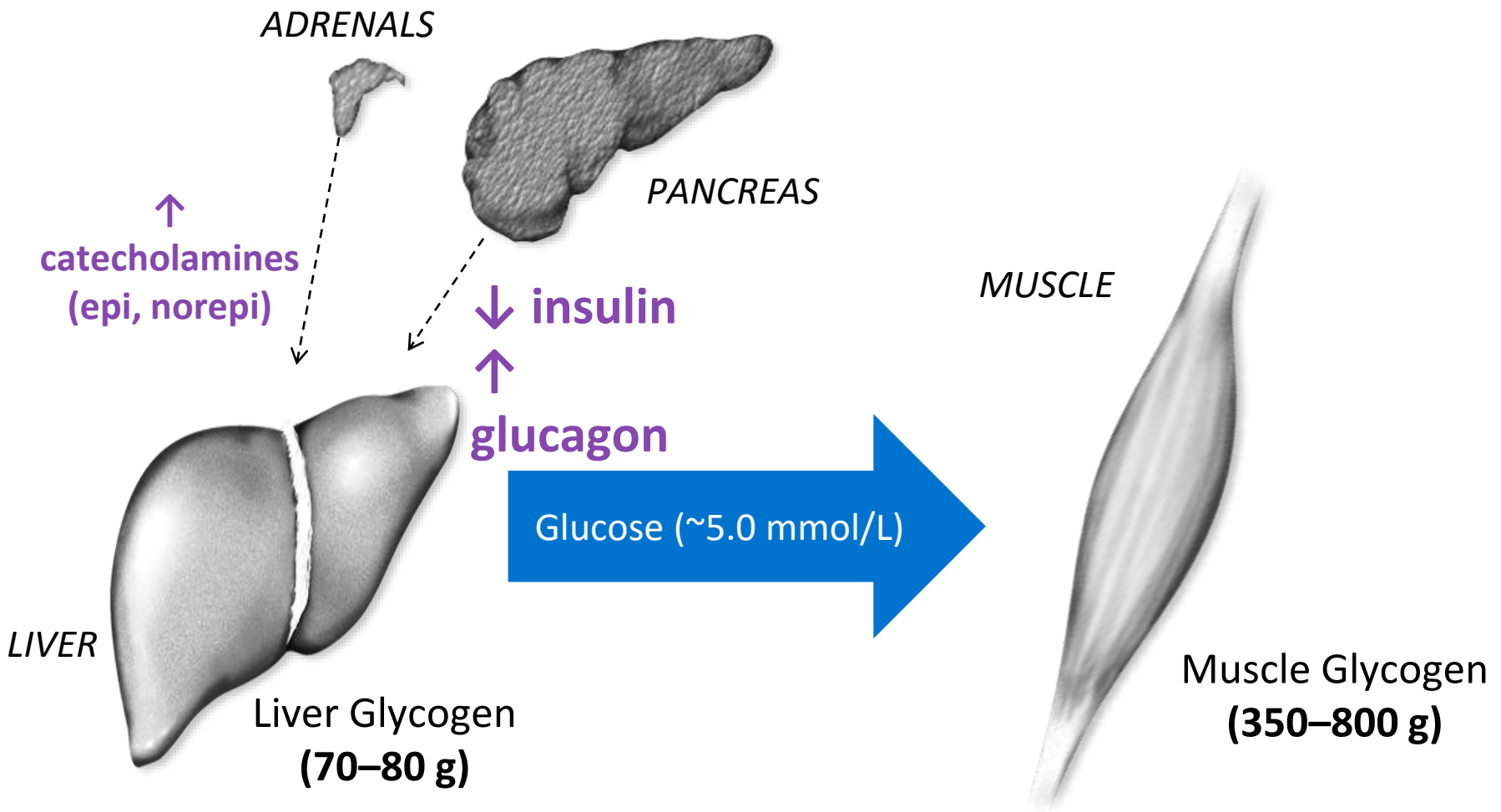
Gavin

Age	22-year-old male
Duration of Diabetes	8 years
BMI	26 kg/m^2
History	Hypo unaware but otherwise uncomplicated diabetes, CSII, HbA1c 7.0% (53 mmol/mol)
Concerns/situation	Frequent post-exercise hyperglycemia with intermittent episodes of nocturnal hypoglycemia, complaining of variable performance
Exercise routine	CrossFit and cycling

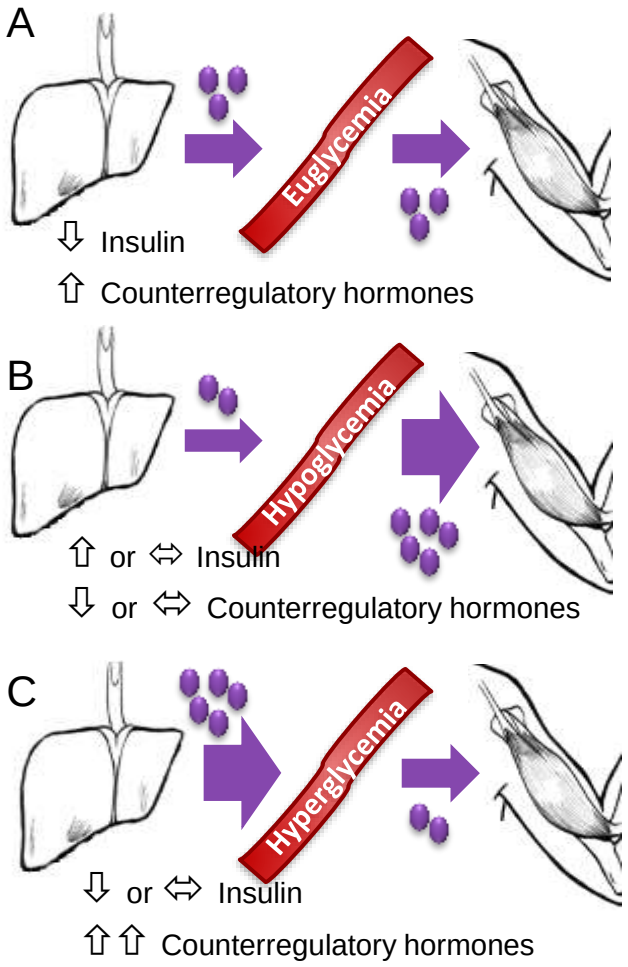
Gavin does not mind the need for extra food (carbs) with exercise as he likes to gain some weight (muscle). What approaches can he use to exercise safely without hypoglycemia and achieve his goal?

Normally, Glucose Provision During Exercise Requires Glycogen Mobilization from the Liver



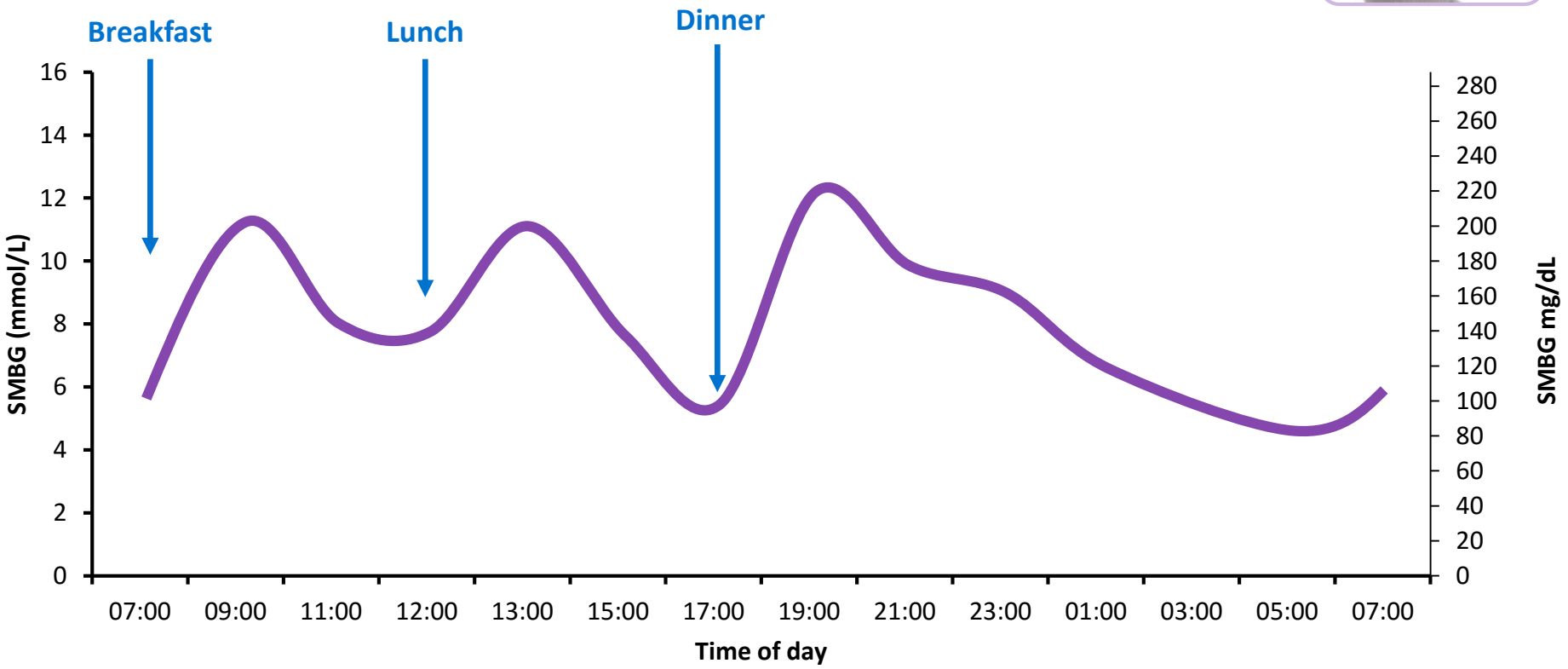
Glucose and Insulin Balance and Imbalance During Exercise

- Euglycemia
  - ⇩ Insulin
  - ⇧ counterregulation (glucagon, growth hormone, cortisol, catecholamines)
- Hypoglycemia
  - Relative hyperinsulinemia
  - Impaired counterregulation
- Hyperglycemia
  - Relative hypoinsulinemia
  - ⇧Catecholamines
  - Anaerobic metabolism (lactate production)



Chu L, Hamilton J, Riddell MC. *Phys Sportsmed.* 2011;39(2):64-77

Sally: Non-Exercise Day Glucose Profile



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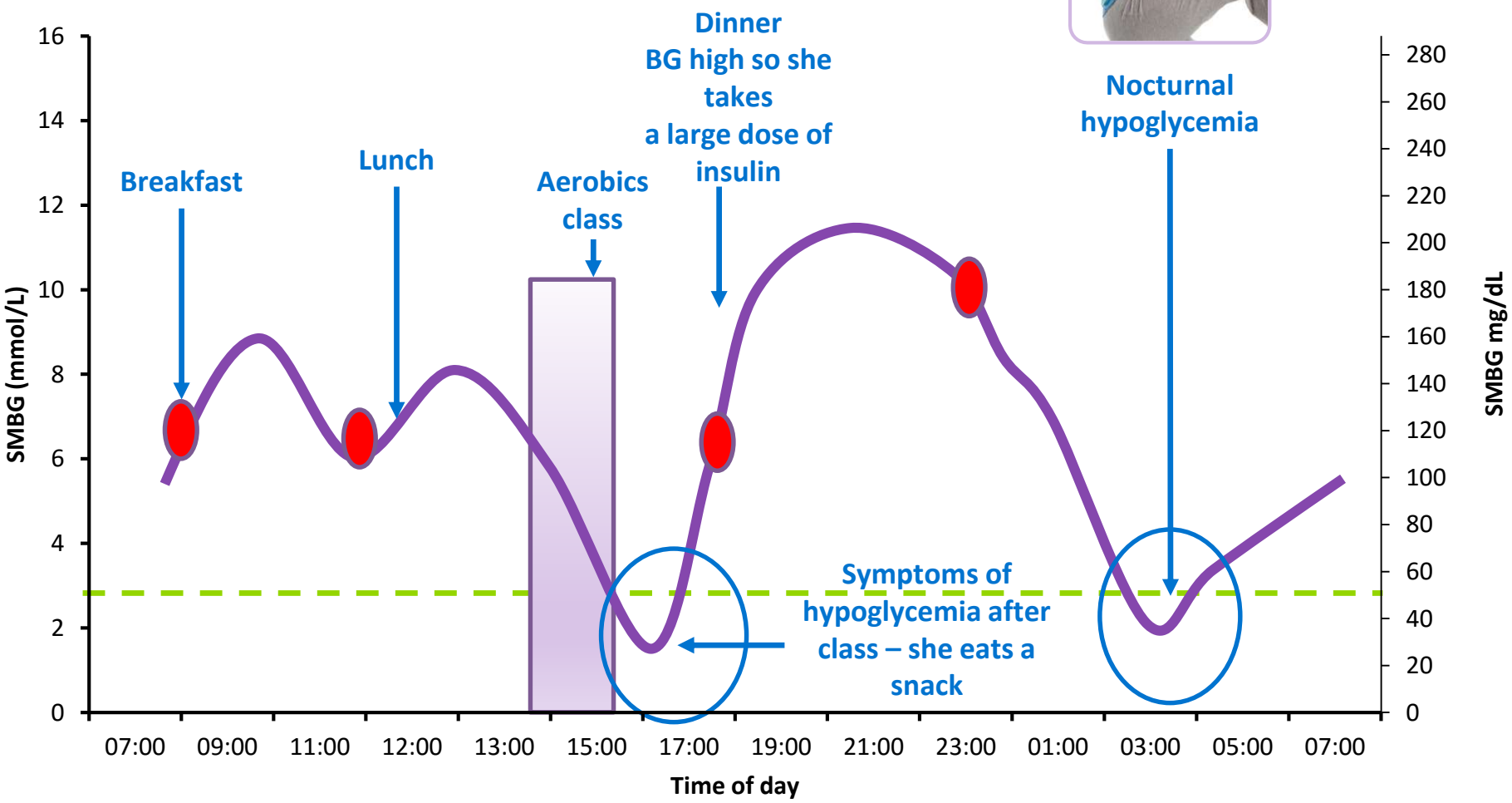

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Question

What is causing the hypoglycemia that Sally is experiencing during exercise?

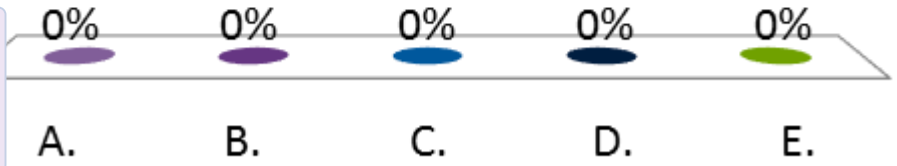
A. Too much insulin

B. Not enough carbohydrate

C. Type of exercise

D. Duration of exercise

E. All of the above



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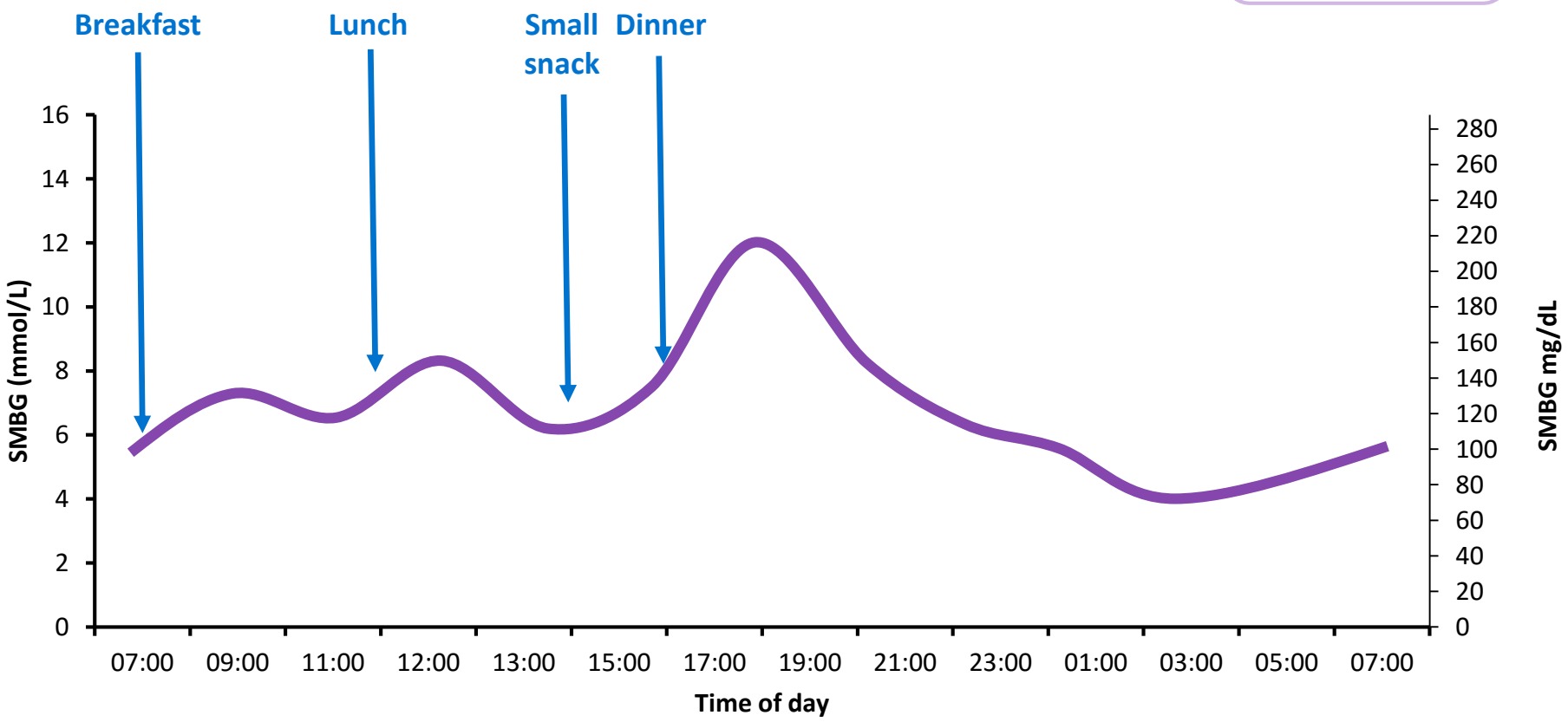
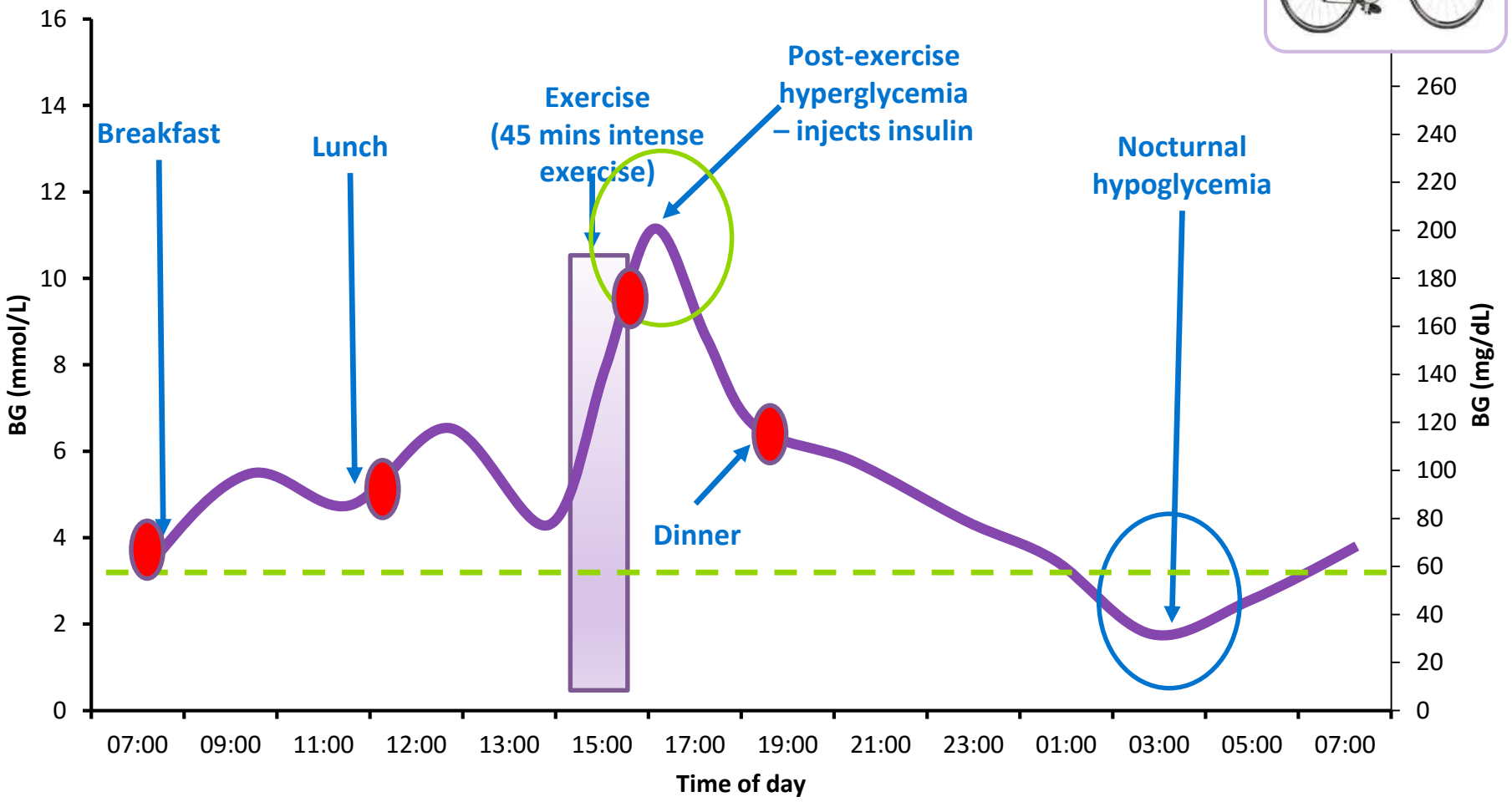
Gavin: Non-Exercise Day Glucose Profile



Gavin: Exercise Day Glucose Profile



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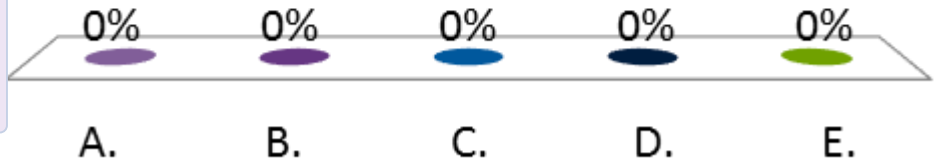

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Question

What is causing the hyperglycemia that Gavin is experiencing after exercise?

A. Too little insulin

B. Too much carbohydrate

C. Type of exercise

D. Duration of exercise

E. All of the above ✓

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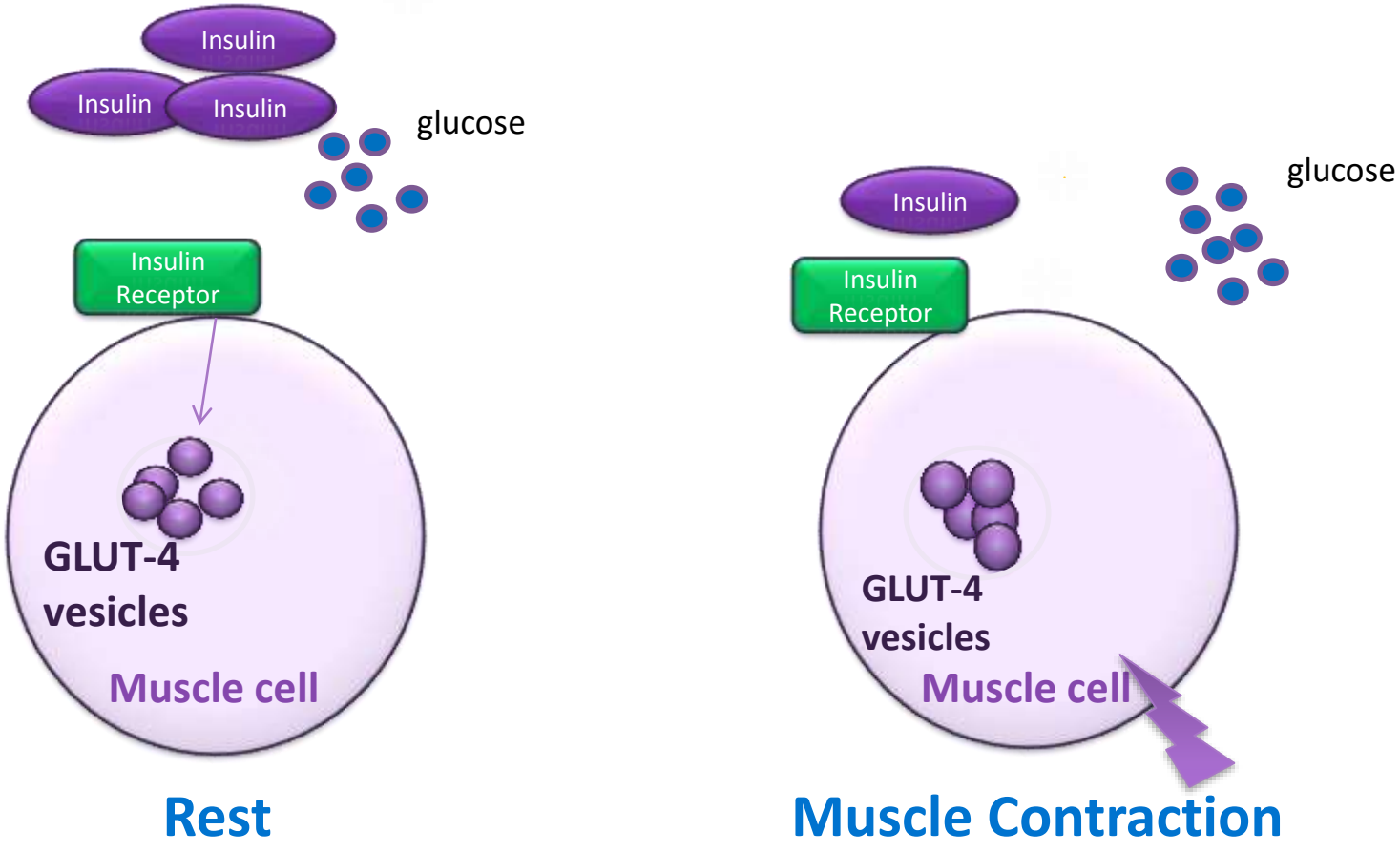
Both Insulin and Contraction Increase Glucose Uptake Into Skeletal Muscle Via Distinct Mechanisms



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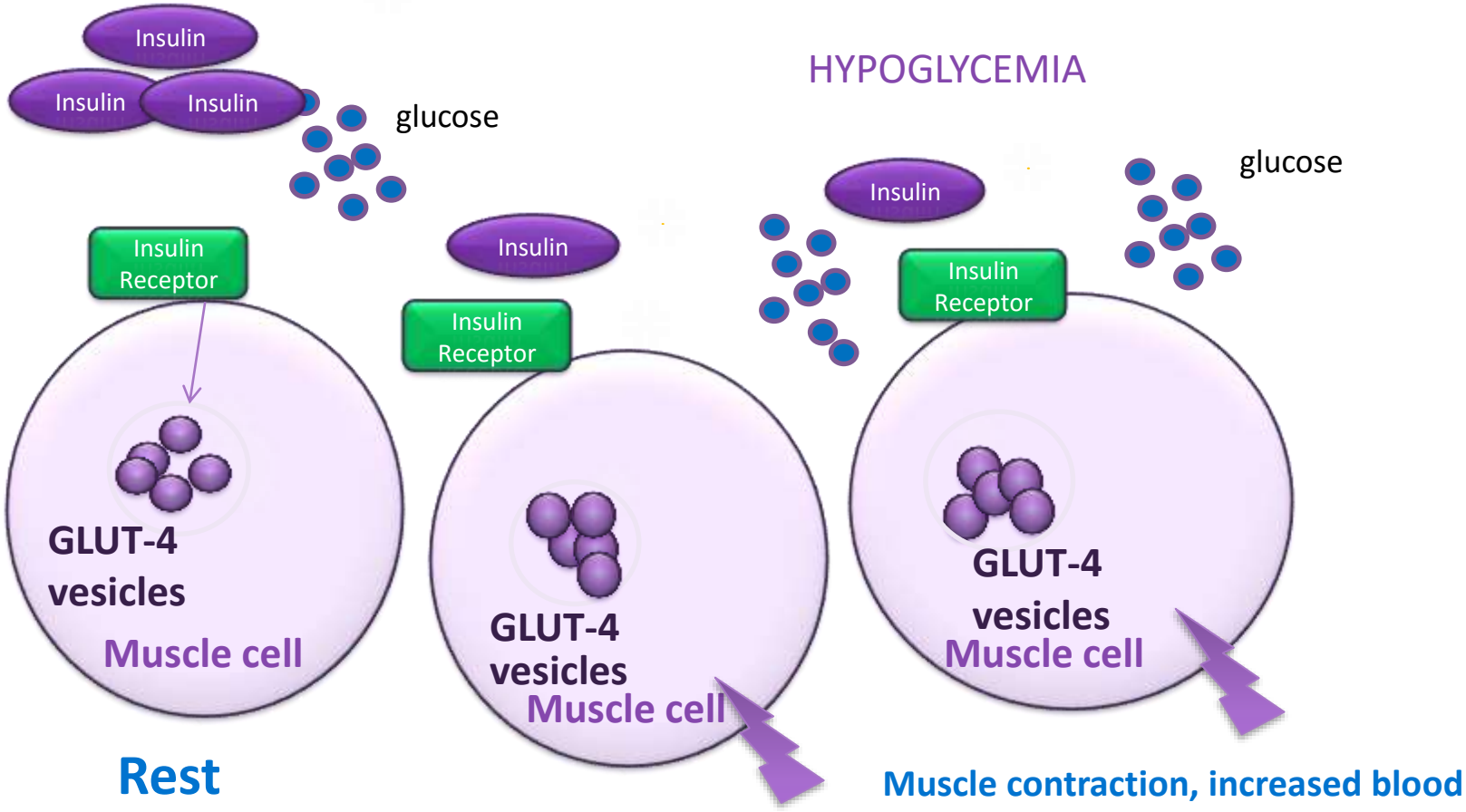
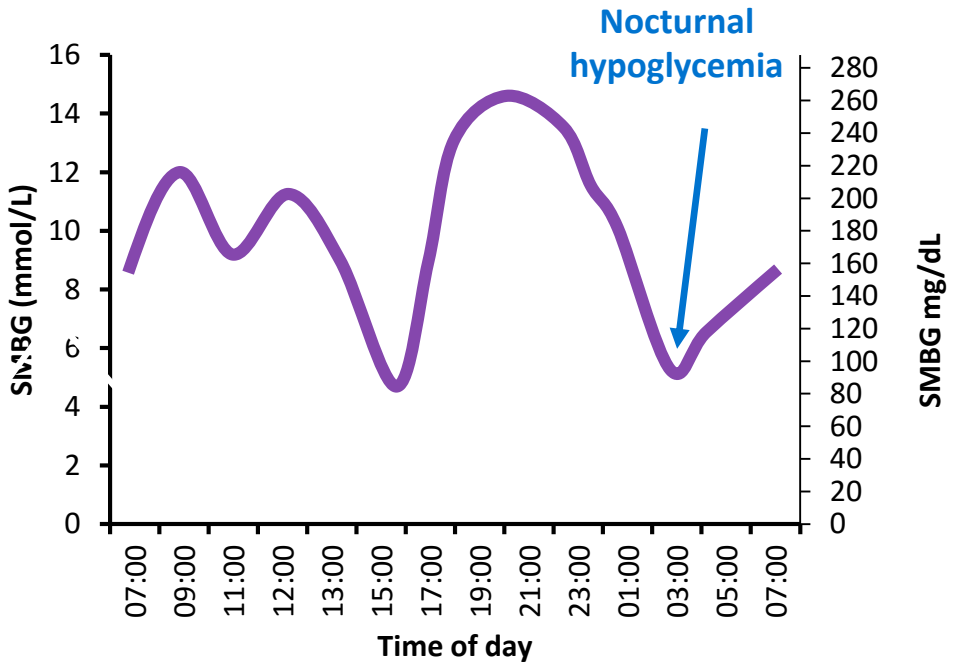


Hyperinsulinemia/muscle contraction, increased blood flood

Post-Exercise Glucose Uptake Remains Elevated for Hours to Replenish Muscle Glycogen Stores



Iscoe *et al., Can J Diabetes* 2008; Jensen and Richter J Physiol 2012

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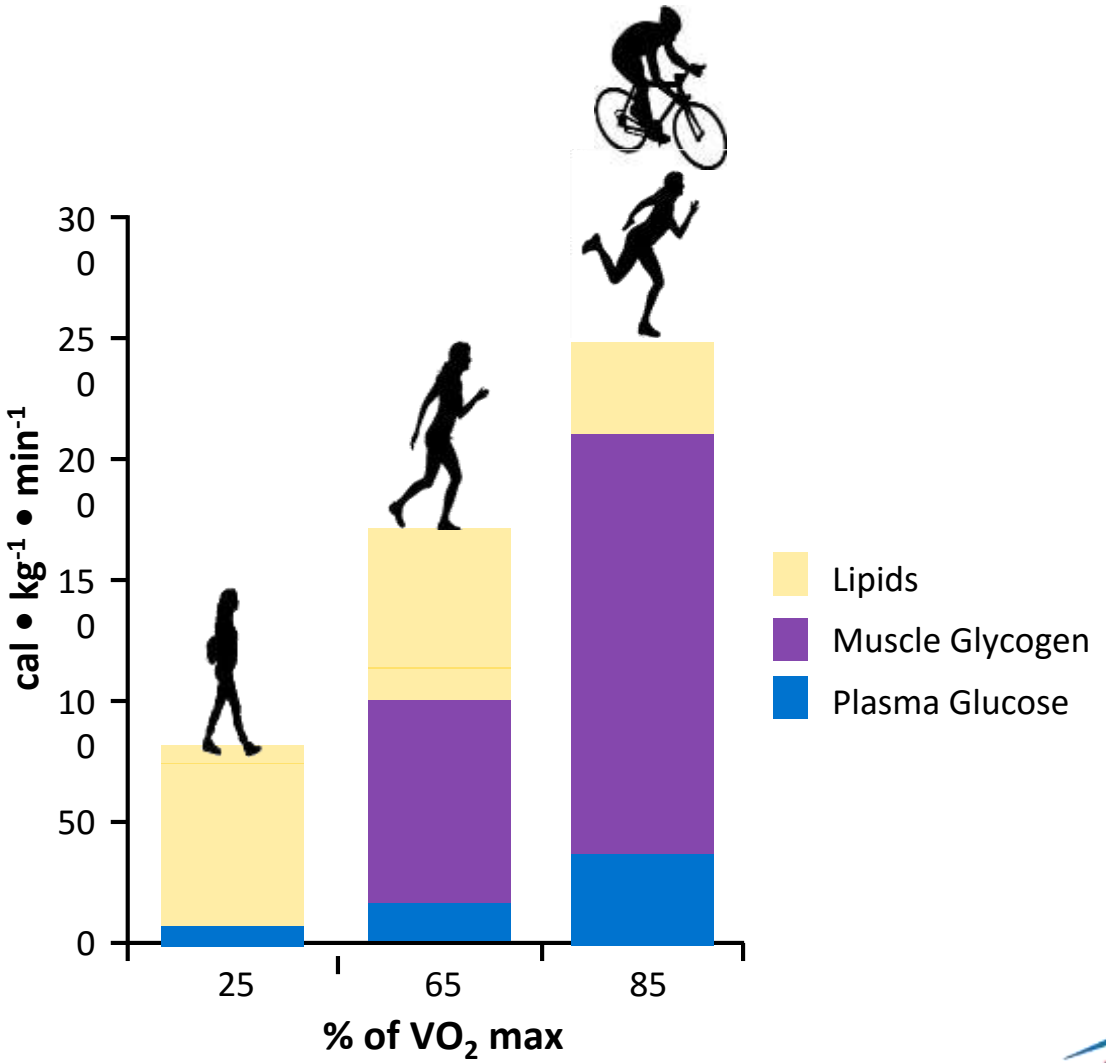
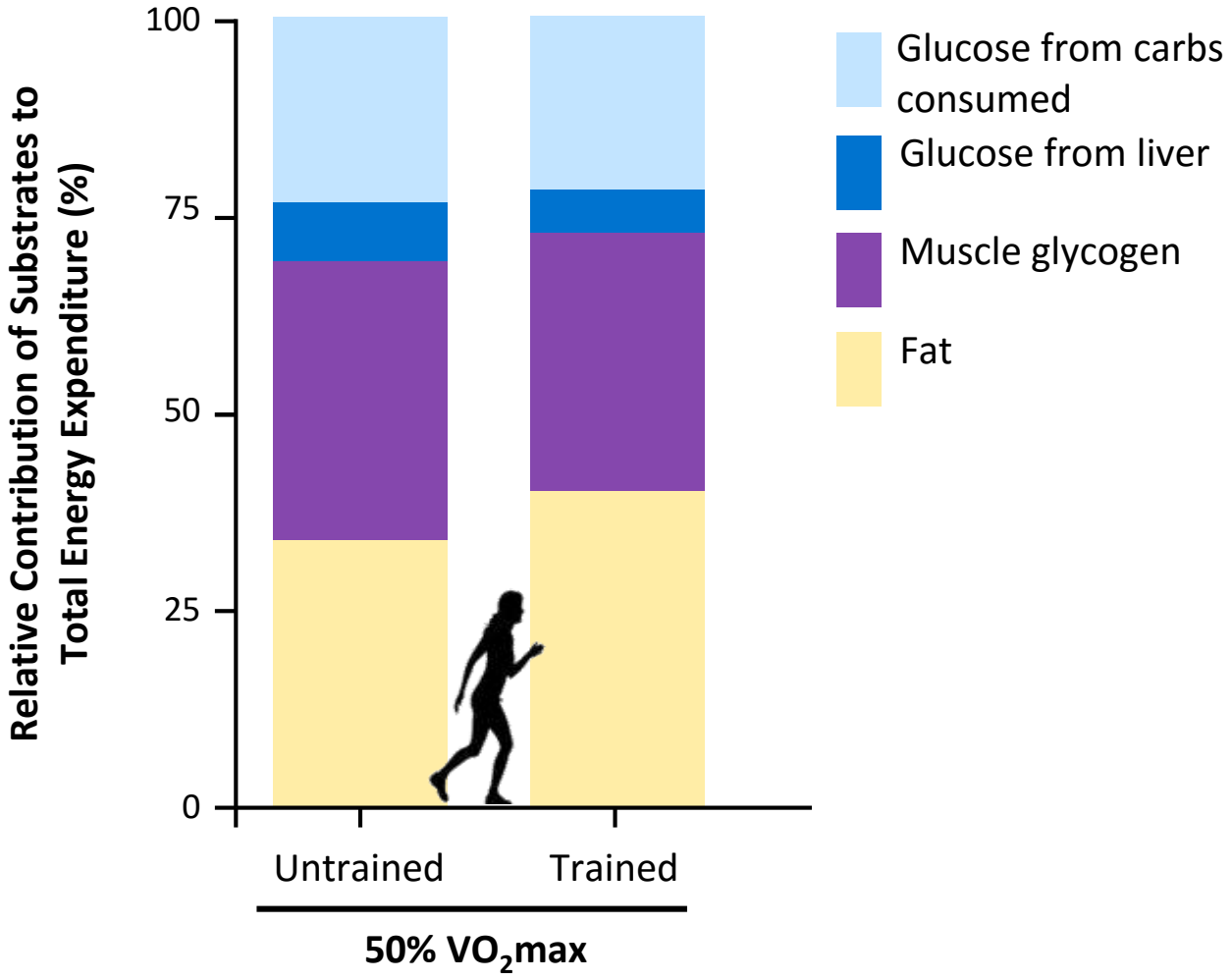
Fuel Utilization: Muscle Glycogen Demand Increases With Intensity

- Lower intensity exercise
  - High lipid (fat) utilization
- Higher intensity exercise
  - High muscle glycogen use
  - High plasma glucose use



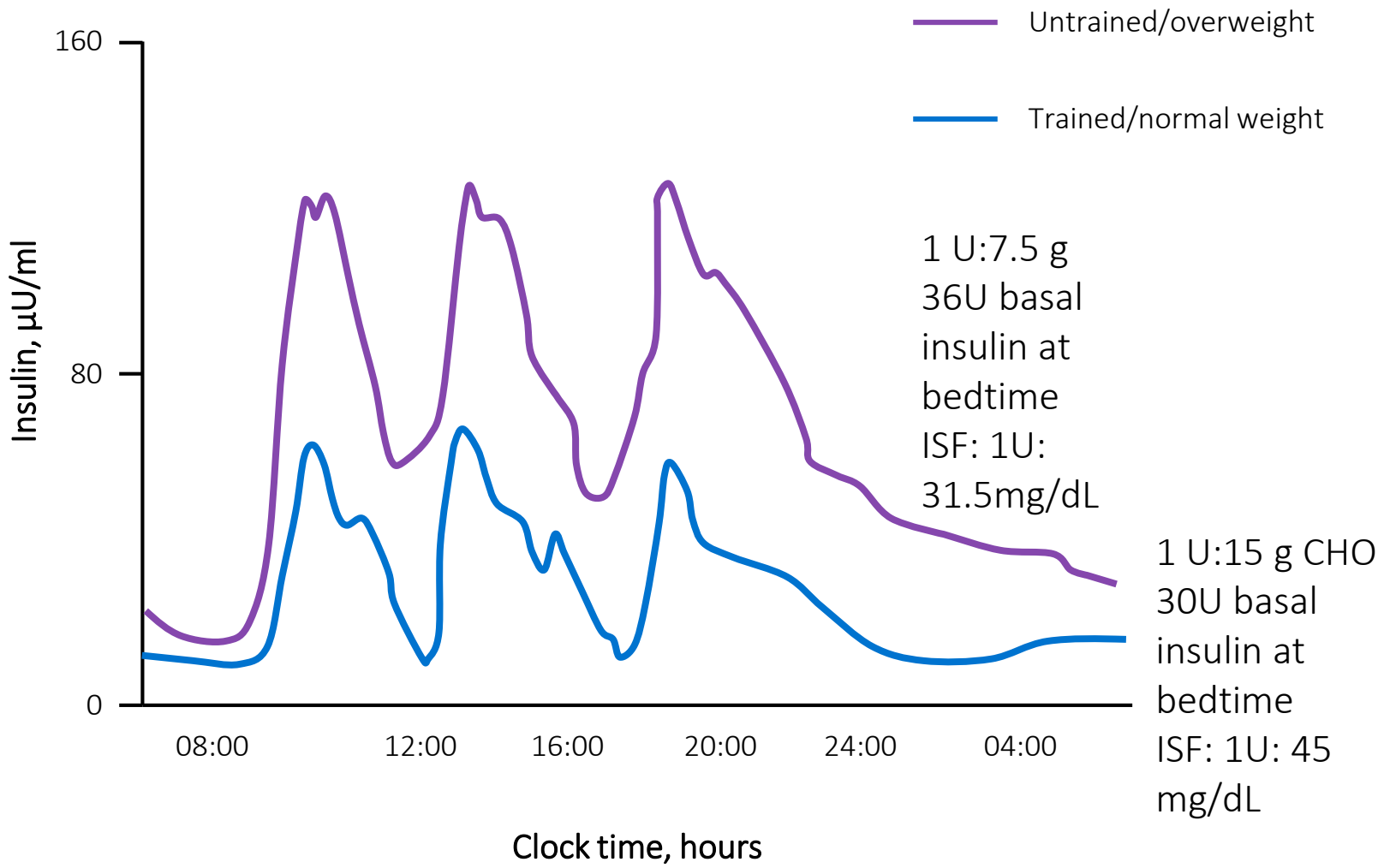
Romijn *et al., Am J Physiol* 1993; Van Loon et al., J Physiol 2001

Training Increases Lipid Use and Spares Muscle And Liver Glycogen

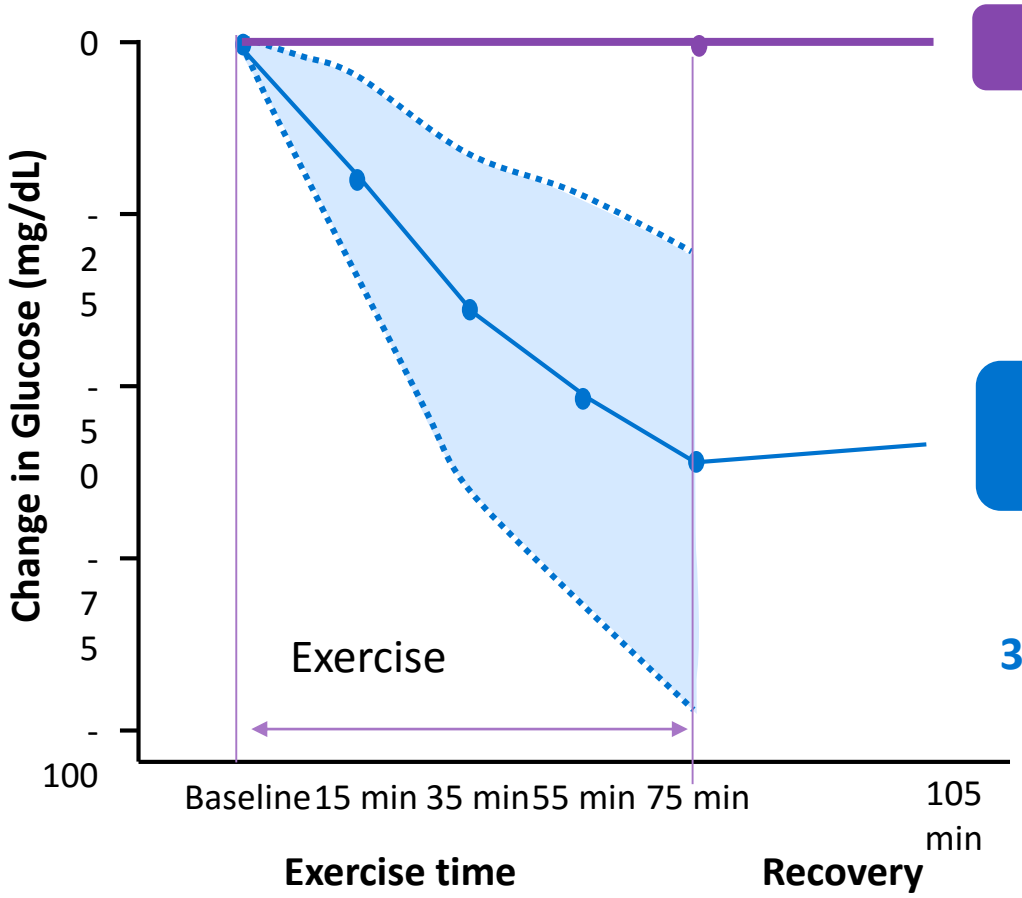


van Loon LJ, *et al. J Appl Physiol* 1999 ;87(4):1413-20

Training Increases Insulin Sensitivity and Lowers Daily Insulin Requirements



Aerobic Exercise Without Adjusting Insulin Promotes a Variable Drop in Glucose and May Cause Hypoglycemia



No diabetes

T1DM, no insulin adjustment

3.6 mmol/L

Δ=~ 65 mg/dL

30% become hypoglycemic

T1D, age 10-18 years, n=50
75 min of intermittent aerobic exercise at ~60% VO2max

The Diabetes Research in Children Network (DirecNet) Study Group Diabetes Care 2006;29:20-25

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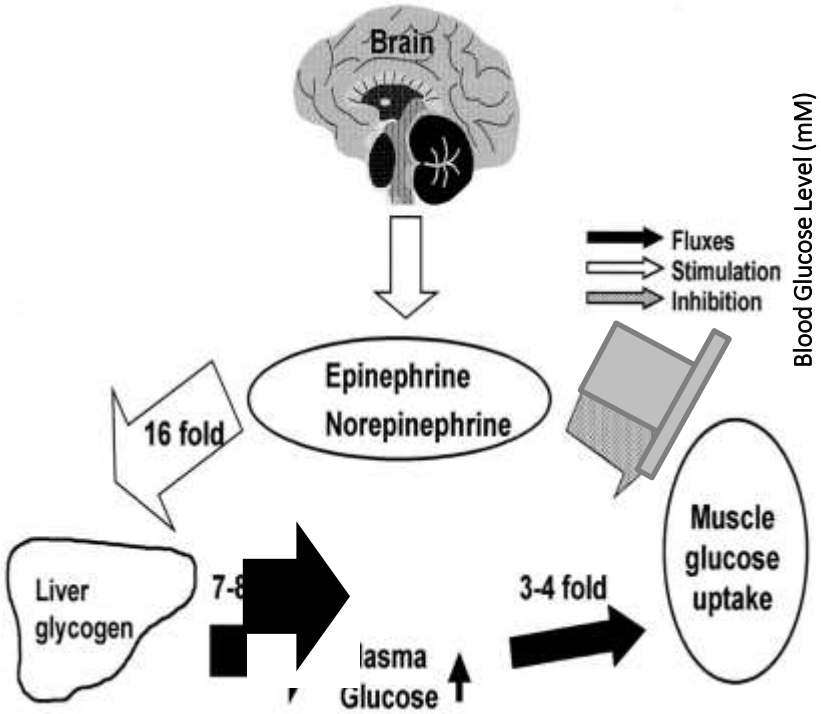
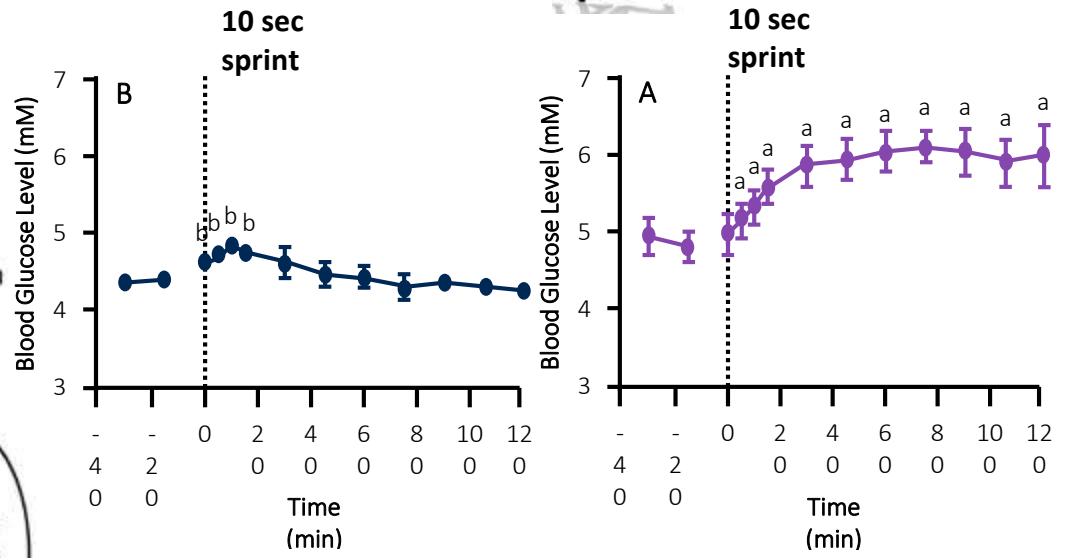
Anaerobic Exercise Can Cause Hyperglycemia and May Increase Insulin Needs During Recovery



Controls

Type 1 Diabetes



Insulin release is able to control glucose rise in controls

Without insulin administration, glucose rise is unchecked in type 1 diabetes

Marliss and Vranic *Diabetes* 2002; Fahey *et al., JCEM* 2012

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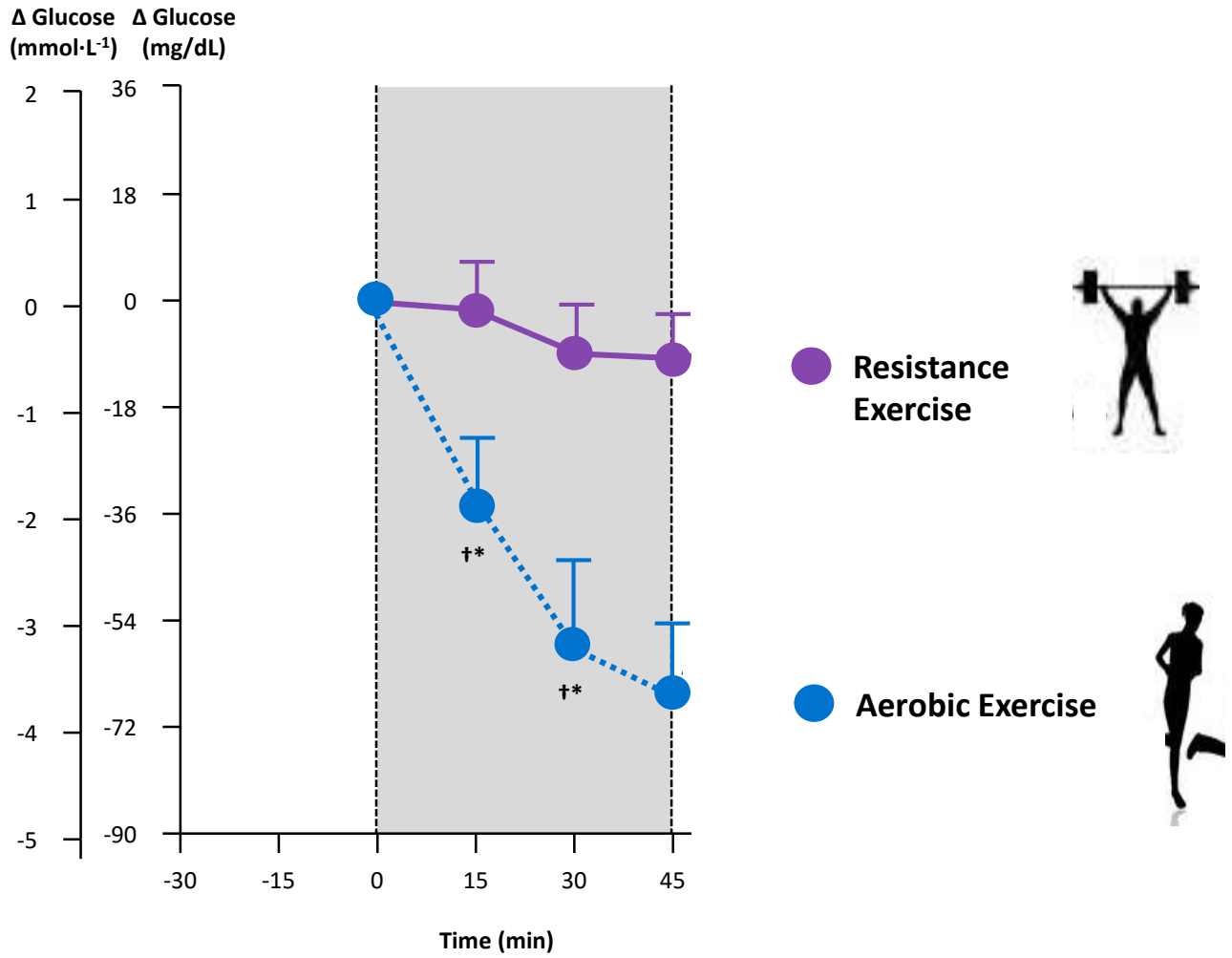
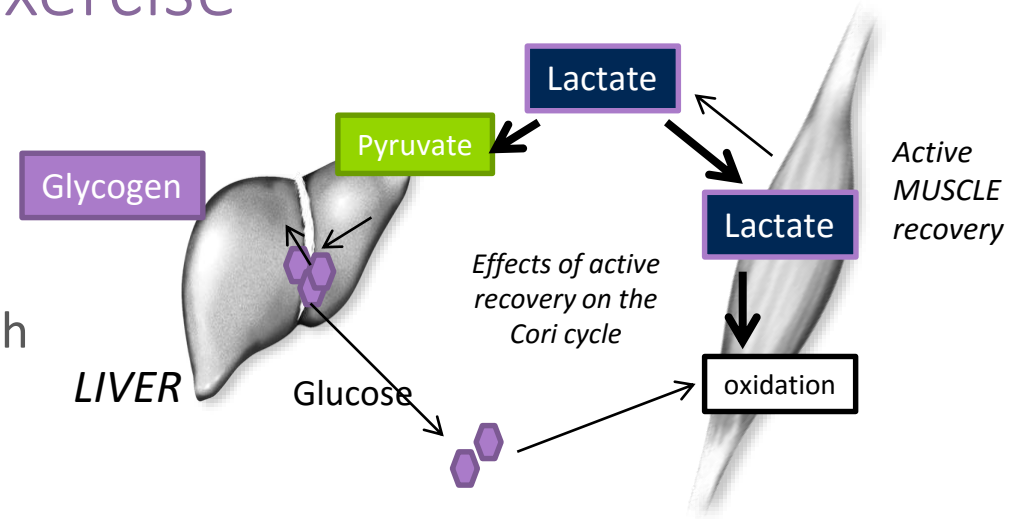
Resistance Exercise Results in a More Stable Glucose Profile
Aerobic vs Resistance Exercise in T1D

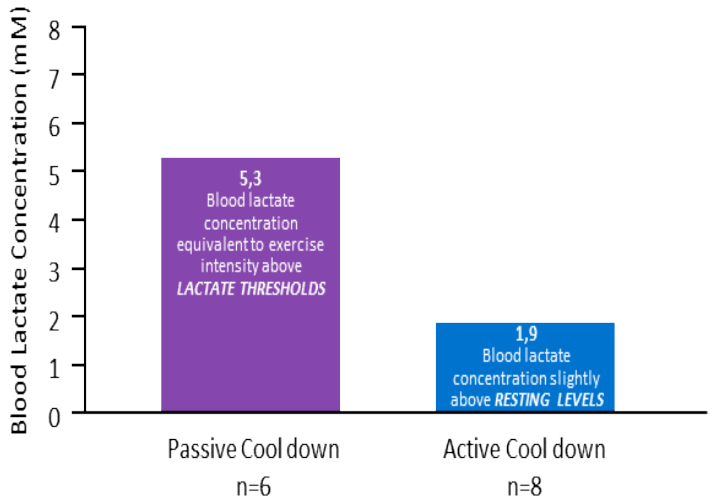


Modified from Yardley et al. *Diabetes Care*. 2012;35(4):669-75.

Early Recovery From Vigorous Exercise

- Counterregulatory hormones and high lactate levels may increase blood glucose levels in early recovery
- Hyperglycemia in early recovery can be attenuated by a prolonged passive cool down at a moderate intensity (30–50% VO_{2max})
- Monitoring of glucose is essential



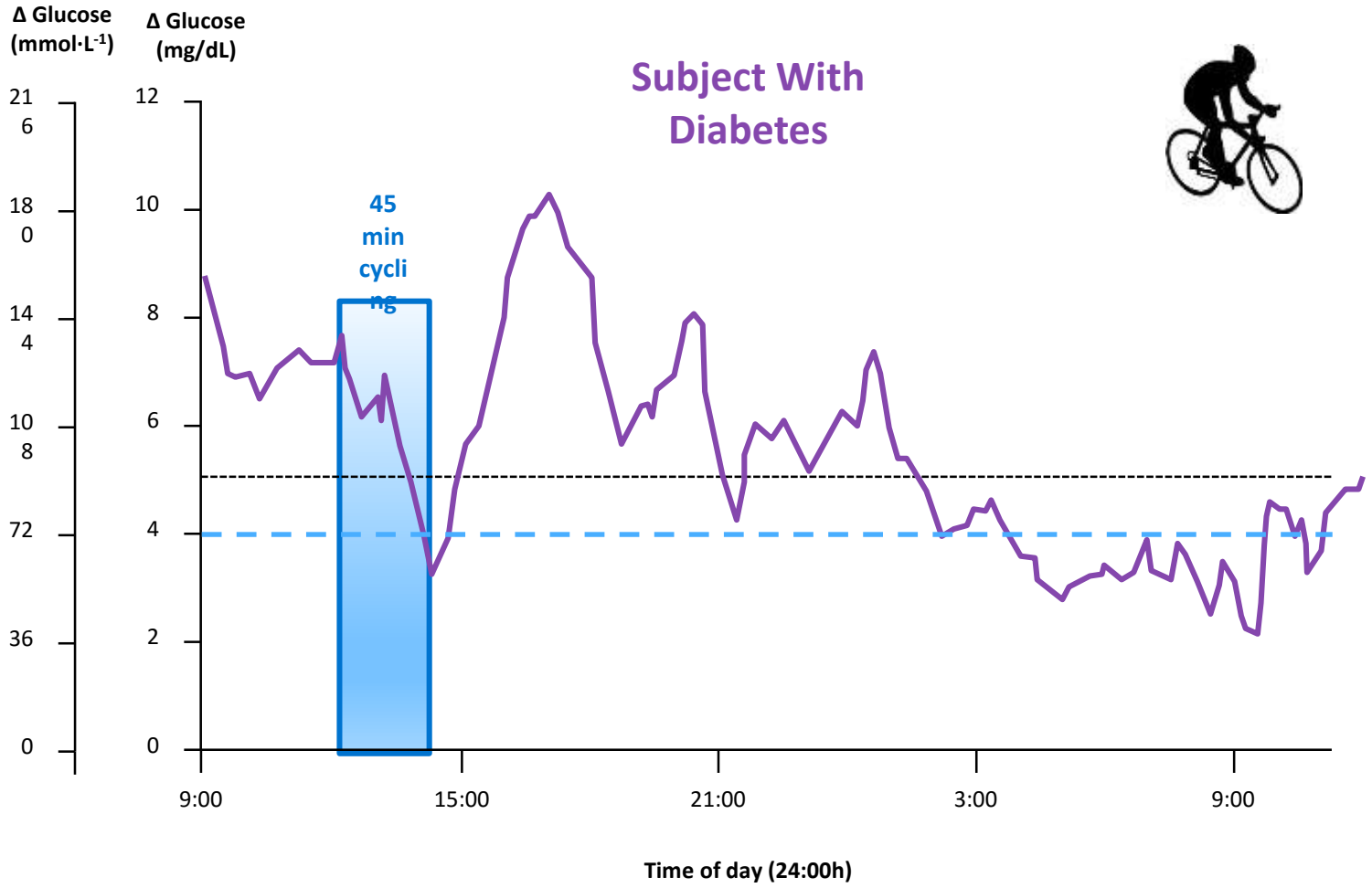


Top: Modified from Exercise Physiology Energy, Nutrition, & Human Performance 6th edition Editors: William D. McArdle, Frank I. Katch, Victor L. Katch. Bottom : Data courtesy of Dr. Iñigo San Millán

Warm-Up and Cool Down Recommendations

- Example of Gavin
  - Before Exercise:
    - If hyperglycemic (≥14 mmol/L) and ketotic (≥1.0 mmol plasma ketones) because of insulin deficiency, don't exercise until hyperglycemia and ketones restored with insulin
    - If mildly hyperglycemic (8-14 mmol/L) do a 10-15 min mild aerobic warm-up
  - After Exercise:
    - Always cool down for ~20 mins - aerobic, easy intensity
    - Consider conservative insulin correction if remain hyperglycemic (12.2 mmol/L)

Lows Beget Lows



Iscoe KE et al. *Diabetes Technol Ther* 2006 Dec;8(6):627-35

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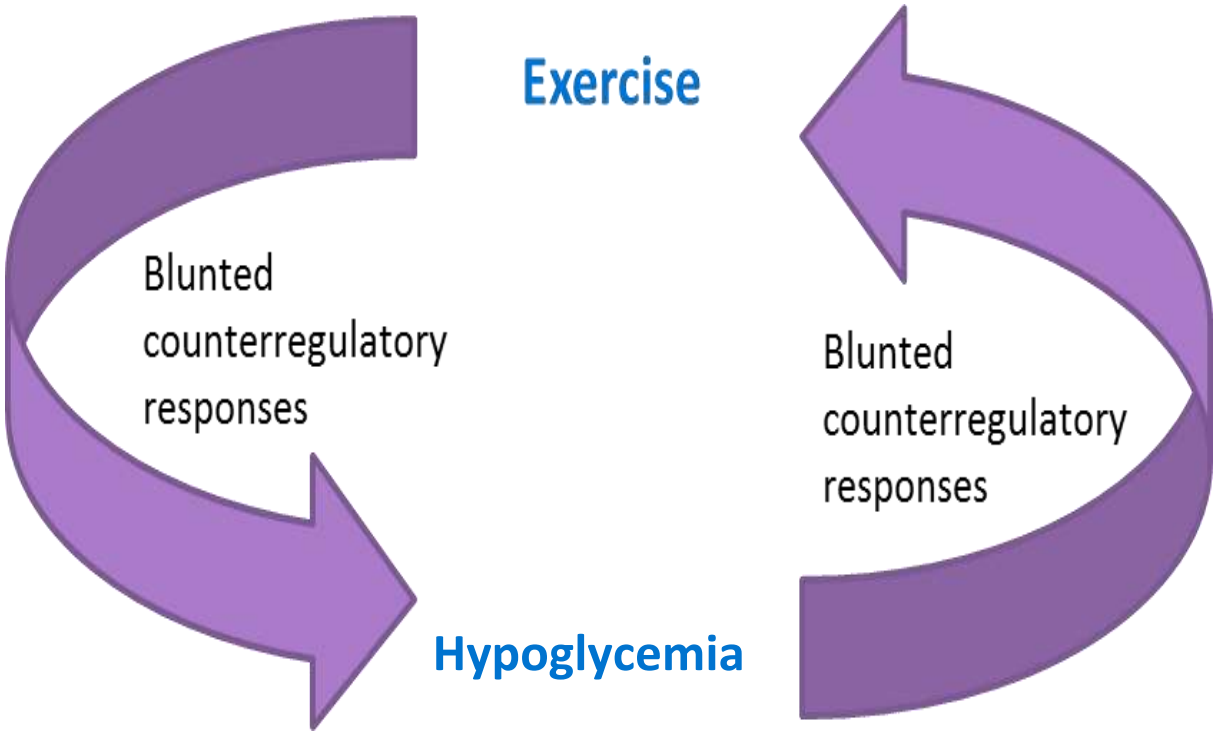
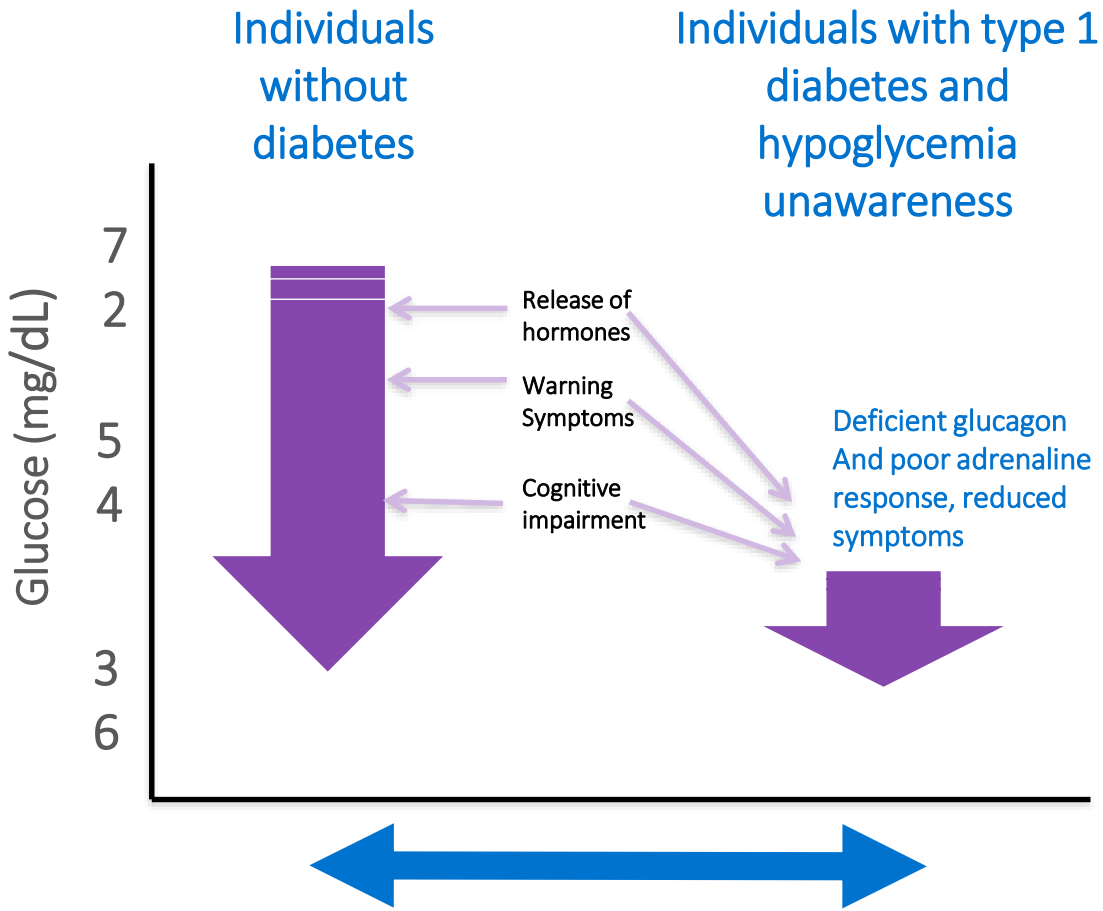
Vicious Cycle of Hypoglycemia and Exercise



Hypoglycemia in Type 1 Diabetes



Martin-Timon and Canizo-Gomez. *World J Diabetes* 2015; 6(7):912–926

Summary

- A basic understanding of the physiological responses to different forms of exercise is essential to best facilitate the following patient goals .....
- Pre-, during, and post-exercise glucose control
- Weight management
- Exercise performance

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Pauze

- De pauze vindt plaats in de Molenhoek.
- Het vervolg van de plenaire lezingen gaat om 11.10 uur van start in deze zaal.
- Mocht u vragen hebben, dan kunt u bij de balie van Health Investment terecht

NUTRITION

RENGER WITKAMP

Disclosures Renger Witkamp

Geen (potentiële) belangenverstrengeling	
Voor bijeenkomst mogelijk relevante relaties	**Bedrijfsnamen**
•Geen	• • • • •

Objectives

- Review the goals of nutrition management for the active person with Type 1 Diabetes
- Identify the key areas of nutrition advice to support goals for exercise
- Identify the key questions to ask to provide individual nutrition advice
- Consider where evidence from nutrition and sports performance can be applied to people with type 1 diabetes

GOALS OF NUTRITION FOR ACTIVE PEOPLE WITH TYPE 1 DM

Goals of Nutrition Therapy in Diabetes Management

Goals of nutrition therapy for people with T1DM:

1. Promote healthy eating patterns to attain glycemic management, BP and lipid goals, achieve and maintain body weight goal, and prevent diabetes complications
2. Address individual nutrition needs
3. Avoid restrictive meal patterns
4. Provide practical tools for day to day meal planning
5. Achieve normal growth and development (Children and adolescents)

Foundations of care: education, nutrition, physical activity, smoking cessation, psychosocial care, and immunization. *Diabetes Care* 2015;38 Suppl:S20-30. American Diabetes Association.
Smart CE, *et al. Pediatric Diabetes* 2014: 15 (Suppl. 20): 135–153.

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Goals of Nutrition in Sport

- Meet the energy and fuel requirements of the sport
- Achieve and maintain ideal physique
- Enhance adaptation and recovery between training sessions
- Reduce sickness and injury during intense training by supporting immune function
- Consider and evaluate the use of nutritional supplements
- Promote long term health

Nutrition and Athletic Performance. American College of Sports Medicine. Academy of Nutrition and Dietetics. Dietitians of Canada. Medicine and Science in Sports and Exercise. 2016.

What is Your Patient's Exercise Goal?

Weight management ✓

Improvement of fitness ✓

Enhance sports performance ✓

Levels of activity

Light to moderate

Moderateto vigorous

Interval and resistance

Maximal/ SuperMax

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Asking the Right Questions

Background Information

Dietary information

Sport specific information

Medical history & medications

What are their personal exercise goals?

Individualized Assessment

- Weight, height, BMI
- Energy requirements
- Usual diet, food choices and meal-time routines
- Exercise aims e.g. weight loss, training for first 10k run
- Timing and duration of exercise
- Insulin regimen and BG monitoring strategies
- Timing and delivery of insulin with meals/snacks
- Blood glucose control (including responses to exercise)

Calculating Energy Requirements

Predictive Formulas

- A number of predictive formulas are available – choice will depend on population
- May over estimate energy requirements
- May be used in conjunction with Physical Activity Factors or METs (Metabolic equivalents)

Example

- Estimating daily energy needs:
  - Determine basal metabolic rate (BMR) or resting energy expenditure (REE) using predictive formula
    - Formulas may have limiting factors
    - Katch –McArdle formula needs lean body mass
    - Harris – Benedict equation limitations include ethnicity
  - Use an activity factor to calculate daily energy expenditure
  - Different definitions of physical activity factors

1. Ridley, K, *et al. International Journal of Behavioral Nutrition and Physical Activity,* 2008; 5(1):45;
2. Ainsworth, BE, *et al*. *Medicine and science in sports and exercise,* 2000;32 Suppl 1): S498-S504;
3. Ainsworth, BE., *et al*. *Medicine and science in sports and exercise,* 2011;43(8): 1575-1581.

Sally

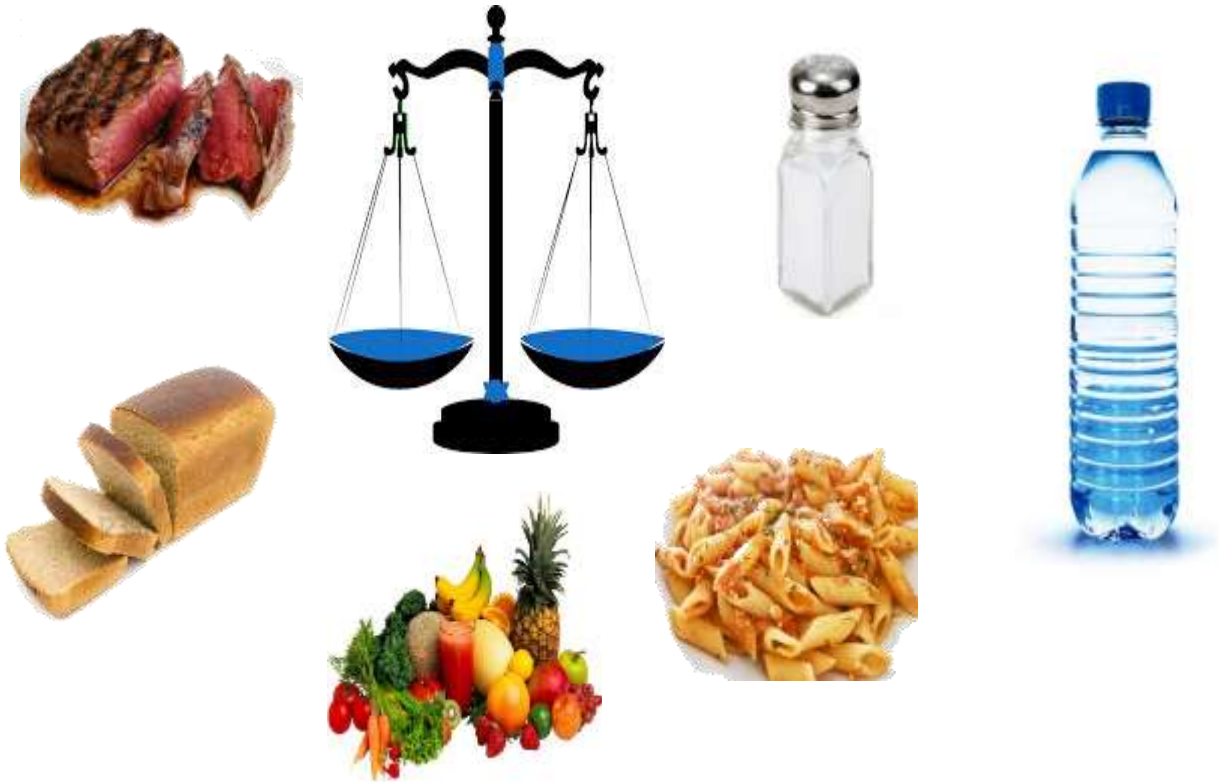
Age	38-year-old female
Duration of diabetes	7 years
Weight	176 lb (80 kg)
Height	5 ft 7 (170 cm)
BMI	28 kg/m^2
Exercise	Aerobics class 2 x 60mins/week and brisk walking
Estimated Energy needs (weight maintenance) – Active day	**Using Harris – Benedict** **1556kcal (REE)** x 1.375 = 2140kcal
Estimated Energy needs (weight maintenance) – Inactive day	Using Harris – Benedict 1556kcal (REE) x 1.2 = 1867kcal
	Reduce energy intake by 239-358kcal/d if weight loss is desired

MEAL PLANNING FOR SPORTS & DIABETES

Question

From the options below please indicate the nutritional components that you feel are of the highest priority for Sally (*select all that applies most)*

- Protein
- Carbohydrate
- Energy Balance
- Iron Supplements
- Salt
- Fluid



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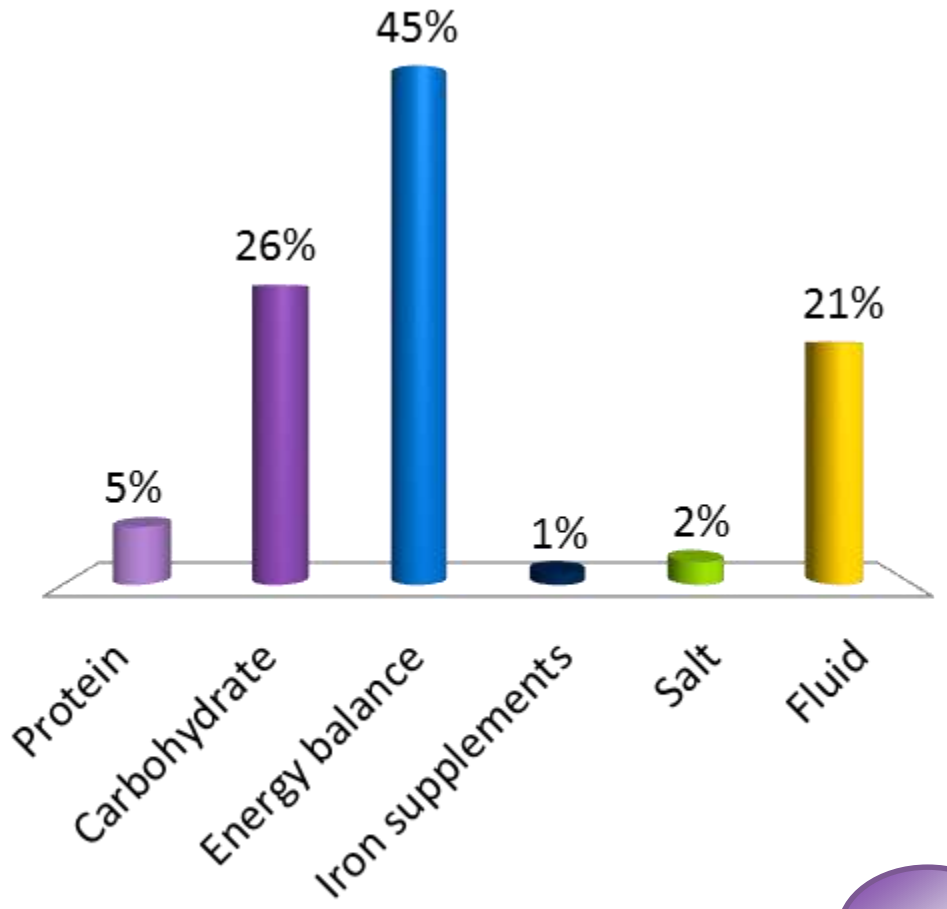
A. Protein
B. Carbohydrate
C. Energy balance
D. Iron supplements
E. Salt
F. Fluid



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General Carbohydrate Recommendations

- Carbohydrate is the major fuel source for exercise performed at 60-70% $VO_{2\ max}$
- Requirements will vary widely
- If performance is not a goal and exercise is at low intensity then 3-5g CHO/kg Body Weight per day is likely to be adequate
- **Carbohydrate may be needed during exercise for either performance or hypoglycemia prevention or both**
- Distribution and timing of carbohydrate intake is important
- **1 – 1.2 g/kg during first 4-6 hours**

Situation	General CHO Recommendations
Habitual diet	**Light training** 3-5 g/kg/d
	Mod exercise 5-7 g/kg/d
	High (1-3h/d) 6-10 g/kg/d
	Very high (>4-5h/d) 8-12 g/kg/d
Pre event meal eaten 1- 4 hours pre exercise	A minimum of 1-4g/kg BW for exercise > 1 h duration Consider Low GI choices
During activity (> 1 hour)	30-60 g/h (0.5 -1g/kg BW Child)
Ultra Endurance (>3 hours)	Up to 90 g/h Consider High GI choices
Recovery	1 -1.2g/kg during the first 4-6 hours

1. Thomas DT , *et al. J Acad Nutr Diet* 2016; 116 (3): 501-28;
2. Burke LM, *et al*. *Journal Of Sports Sciences*, 2011;29 Suppl 1:S17-S27;
3. Bartlett JD, *et al. Eur J Sport Sci* 2015;15(1):3-12.

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Factors Influencing Carbohydrate Needs and Distribution During Exercise

Blood glucose below 90mg/dL
5.0 mmol/L

Aerobic exercise

New sport/ unfamiliar activity

Competition

Anaerobic exercise

Short duration

Fasting exercise

Insulin adjusted with meal prior to exercise

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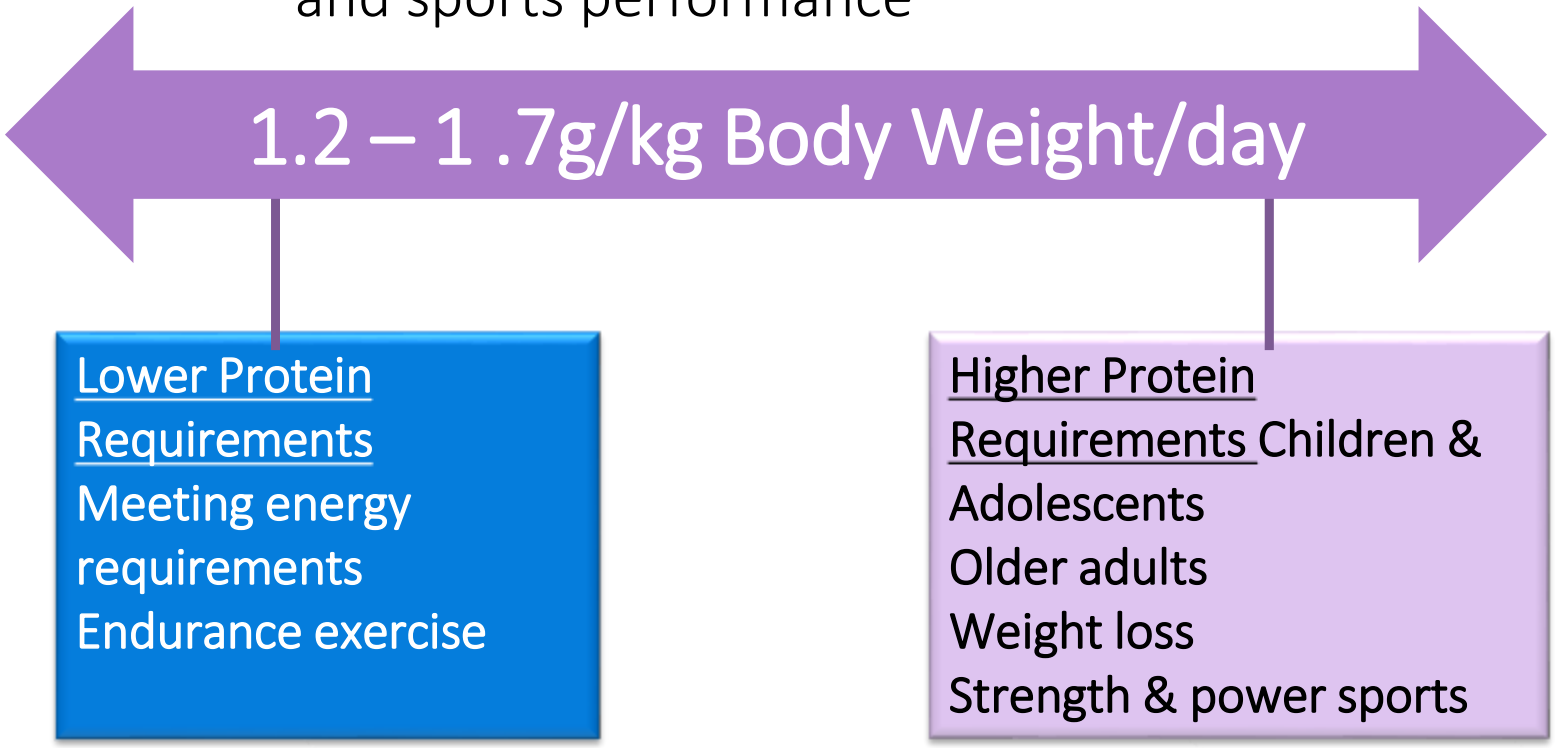
Sally

Age	38-year-old female
Duration of diabetes	7 years
Weight	176 lb (80 kg)
Height	**5 ft 7** (170 cm)
BMI	28 kg/m^2
Exercise	Aerobics class 2 x 60 mins/week and brisk walking
Estimated Energy needs (weight maintenance)	**Using Harris – Benedict 1556kcal (REE) x 1.335 = 2077kcal**
Weight loss	**Reduce energy intake by 3-500kcal/d depending on activity energy expenditure**
Carbohydrate req's	240g/d (may use increased protein to meet energy needs and promote weight loss with decreased energy intake)

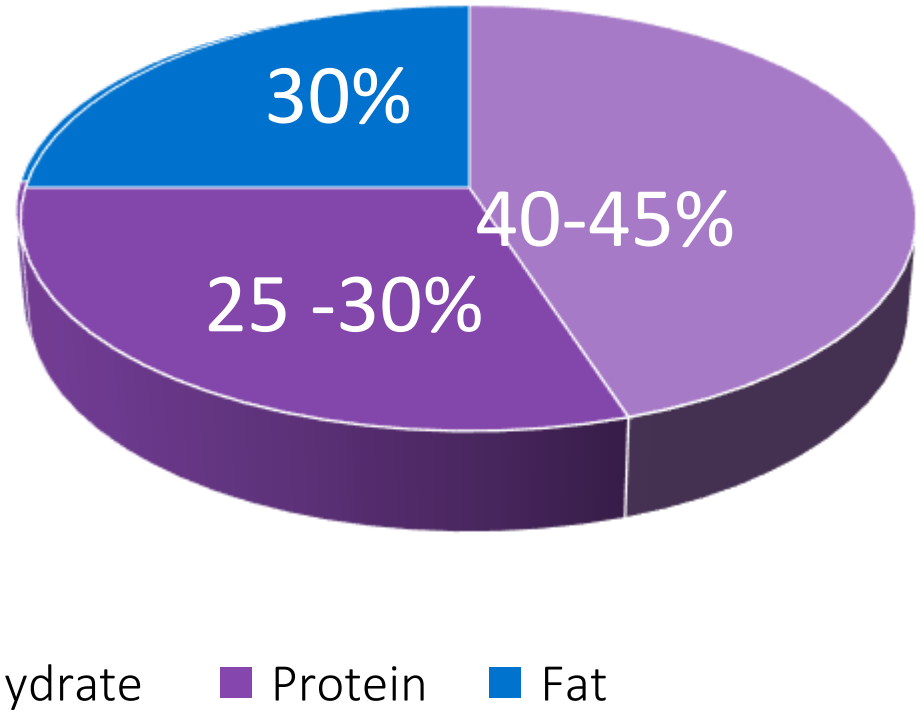
Daily Protein Requirements for Sports

Protein intake is important for muscle recovery and repair, growth, and sports performance



1. ADA and collaborators. *Med Sci Sports Exerc*. 2009; 41(3):709-31;
2. Phillips, SM. *Sports Medicine*, 2014;44 Suppl 2:149-153;
3. Phillips, SM, *et al*. *International journal of sport nutrition and exercise metabolism, 2007;* 17: S58.

Composition of the Diet– Weight Loss



Getting it Right with Food - Plan, Plan, Plan

- Distribute food across day to fuel body
  - Timing of both carbohydrate and protein foods important
- Education about portion sizes and amounts needed
- Particularly need to include iron- and calcium-rich foods
- Appropriate insulin adjustment to carbohydrate intake. May need to consider glycemic impact of high fat and protein foods

Nutrition Before Exercise

	1-4 hours	Within 10 -15 minutes
Carbohydrate	A meal based on low fat low GI carbohydrate 1-4 g/kg BW	Depending on BGL and IOB and activity type.
Protein	Include 20-30 g low fat high quality protein e.g. lean meat, fish, milk, yogurt	Not required
Fluid	5-10 ml/kg BW in the 2-4 hours before exercise	Between 150 – 300ml fluid depending on age/sex/environment

1.Thomas DT , *et al. J Acad Nutr Diet* 2016; 116 (3): 501-28;
2. Burke LM, *et al*. *Journal Of Sports Sciences*, 2011;29 Suppl 1:S17-S27;
3. Coyle, E. Journal of Sports Sciences. 2004;
4. Phillips, SM. *Sports Medicine*, 2014;44 Suppl 2:149-153;
5. Phillips, SM, *et al*. *International journal of sport nutrition and exercise metabolism, 2007;* 17: S58.

Pre-Exercise Meals and Snacks

Lean meat and cheese roll or wrap

Pasta and lean meat

Fruit smoothie

Breakfast cereal and low fat milk

Peanut butter **or baked Beans** on wholegrain toast

Nutrition During Exercise

	30 mins	30-60 mins	60 mins+
Carbs	Not needed unless blood glucose dropping	May be needed if very strenuous activity or no insulin adjustment	May be needed for fuel 30-60g/h
Fluid	Drink appropriate amount* of fluids to replace sweat losses so that total body fluid deficit is <2% BW	Water should be adequate for hydration	May benefit from use of sports drinks

* Depends on exercise intensity, duration, fitness, heat acclimatization, altitude and environment (i.e., humidity)

- Consider when nutrition advice is needed to manage blood glucose and when nutrition advice is about providing adequate fuel for activity

Thomas DT , *et al. J Acad Nutr Diet* 2016; 116 (3): 501-28

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Nutrition After Moderate to Intense Exercise

Carbohydrate

Aim for 1-1.2g/kg BW carbohydrate eaten within
1-2 hours after exercise to replenish glycogen stores

Protein

Addition of 15-25g protein to a meal containing carbohydrate can help to reduce hypoglycemia risk and enhance glycogen synthesis

Fluid

Drink fluids post exercise with food to maximise re-hydration

Thomas DT , *et al. J Acad Nutr Diet* 2016; 116 (3): 501-28

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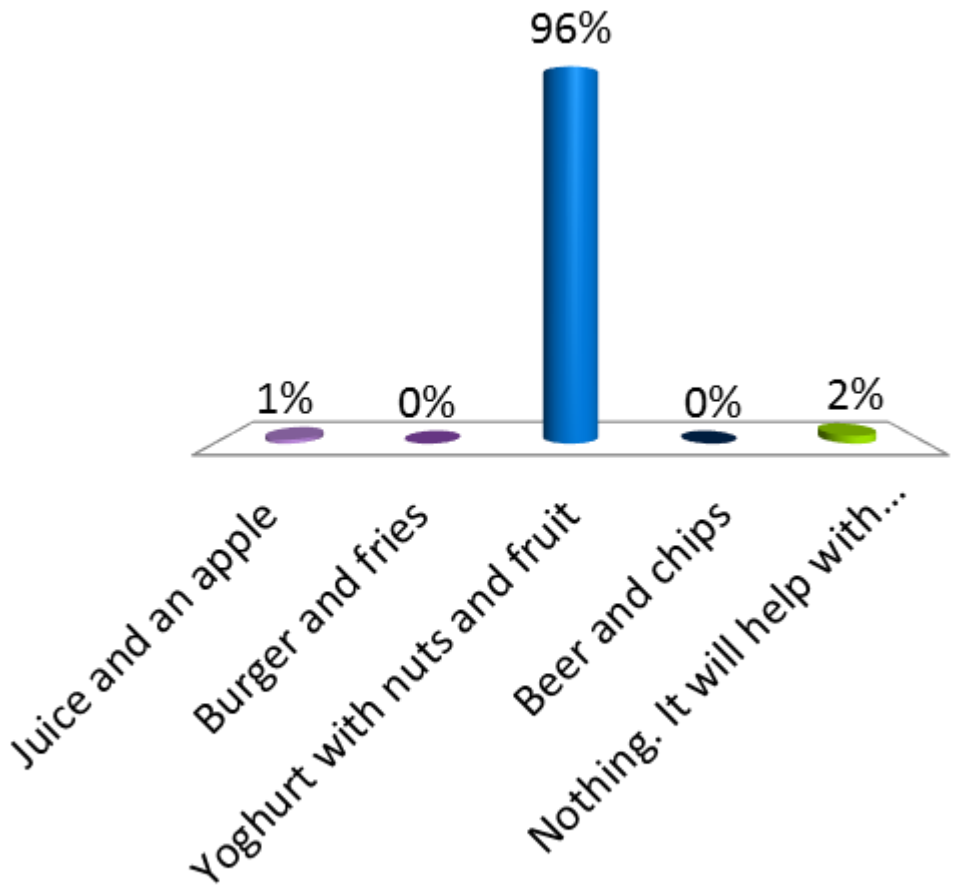
Question

What is a good meal/snack to eat after > 60 mins exercise?

A. Juice and an apple
B. Burger and fries
C. Yoghurt with nuts and fruit
D. Beer and chips
E. Nothing. It will help with weight loss



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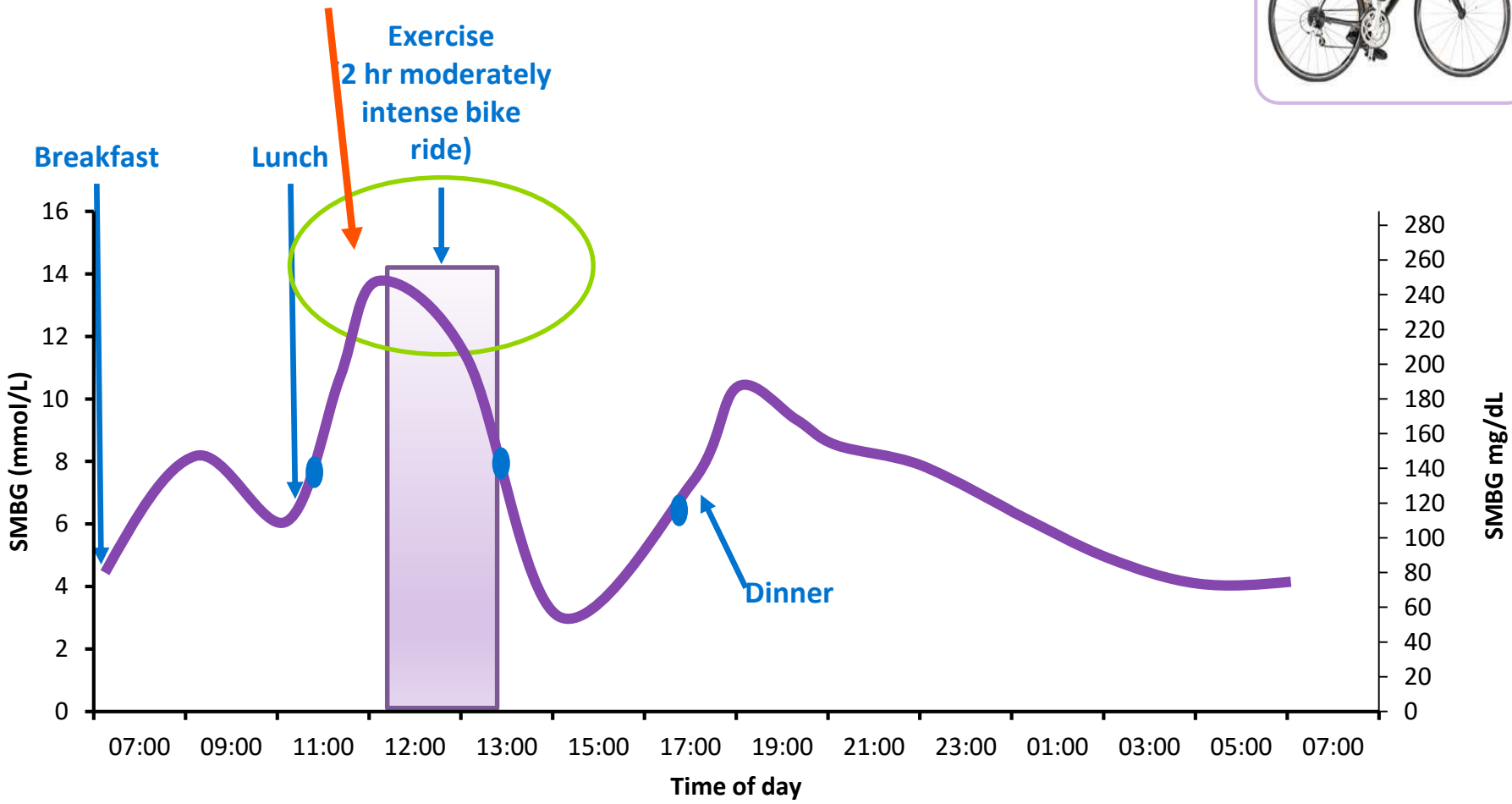
Gavin: Exercise Day Glucose Profile



Dietary Recommendations

Age	22-year-old male
Weight	148lb (67kg)
BMI	19 kg/m^2
Cycling for 2-3 hours twice a week	Daily carbohydrate = 335g/day 30g CHO per hour of cycling. Consider also insulin on board and BGL Post exercise 60-70g CHO with appropriate insulin adjustment. May be split over 2-3 hours post exercise Distribute carbohydrate across day to ensure pre- and post-carbohydrate intake to maximize glycogen stores on active days.

Supplements

Sports Foods
- Useful when active and impractical to consume everyday foods

Sports Drinks
Sports Gels
Liquid Meals
Whey Protein
Sports Bars
Electrolyte Replacement

Medical/nutritional supplements
- Used to treat clinical issues

Iron Supplements
Calcium Supplements
Multivitamins
Vitamin D
Probiotics

Performance Supplements

Caffeine
B-Alanine
Bicarbonate
Beetroot Juice
Creatine

Water or Sports Drink During Exercise?

Water

- Most commonly used
- Minimal side-effects
- Adequate for shorter events (<60 mins)

Sports drinks

- Beneficial for longer events (> 60 -90 mins)
- CHO between 6 and 10% (evidence for 6-8% CHO in youth with T1D)
- Sodium – 230-690 mg/1000 mL
- Be careful not to over-consume

Riddell MC, *et al.* *Int J Sport Nutr* 1999;9(1):24-34

Carbohydrate Gels- Surfing, Cycling etc

Product	Serving size to provide 15g CHO
Glucose Tablets	4 tablets
Glucose powder	1 tbsp (15g)
Polyjoule	2 scoops (16g)
Endura sports gel	20g
GU energy gel	19g
BSc Fuel Energy gel	22g
Powerbar Gel	23g

Fluids with Carbohydrate

Product	Carbs g/L	Carb type	Sodium mg/L	Potassium mg/L
Gatorade	60	Sucrose, glucose	510	230
Powerade	73	Sucrose, maltodextrin	280	141
Lucozade Sport	64	Glucose Syrup	480	60
Lucozade Sport Lite	20	Glucose syrup	0-4	(0)
Powerade Zero	0	N/A	510	97
Gatorade Low Calorie G2	20	Sucrose	450	127
Pump sports water	22	Sucrose	190	47
MiZone water	37	Dextrose, sucrose, fructose	230	0
Orange Juice	55	Fructose, glucose, sucrose	30	1500
Apple Juice	105	Fructose, glucose	40	1010

Sports Drinks (US)

PRODUCT per serve	Cals (kcal)	Carb (g)	Sodium (mg)	Comments
Gatorade G sports fuel	100	100	110	Serve size 118ml
Gatorade G Thirst Quencher	80	21	160	Serve size 355ml
Powerade	80	21	150	Serve size 360ml
Aspire ICE	35	12	95	Serve size 355ml
SIS Go Electrolyte	146	37	200	Serve size 40g powder

Low Carb Diets

ADA Definitions

What is meant by low Carb?

- Very-low-carbohydrate diet: 21– 70 g/day of carbohydrate
- Moderately low– carbohydrate diet: 30 - 40% of energy as carbohydrate
- Moderate-carbohydrate diet: 40–65% of energy as carbohydrate
- High-carbohydrate diet: >65% of energy as carbohydrate

- In sports nutrition literature studies have investigated impact of <25% energy from CHO
- Low Carb High Fat (LCHF) diets impair capacity for high intensity exercise
- Other potential impacts – poor growth, fatigue, high blood fats
- Individual range of carbohydrate requirements exist. **Evidence does not support LCHF as a strategy**

1. Burke L *Sports Med,* 2015;45 Suppl 1:33-49;
2. Wheeler ML*, et al. Diabetes Care,* 2012; 35 (2):434-445.

Disordered Eating and Diabetes

- Research suggests eating disorders are more common in women with diabetes versus women without diabetes (American Diabetes Association)
  - Bulimia is most common in type 1 diabetes ("Diabulimia")
  - Approximately 38% of females and 16% of males with type 1 diabetes have disordered eating behaviors. Hanlan, M. E., Griffith, J., Patel, N., & Jaser, S. S. (2013). Eating disorders and disordered eating in Type 1 diabetes: prevalence, screening, and treatment options. *Current Diabetes Reports*, 13(6), 909-916.
  - Focus on managing diabetes includes weight, food, physical activity. Combined with poor body image or higher concern for weight-gain create an environment that increases the chance for disordered eating.

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Eating Disorders and Athletes

- Higher risk associated with the following:
  - Sports focusing on appearance, weight requirements or muscularity (dance, gymnastics, diving, bodybuilding, wrestling)
  - Sports focusing on performance of an individual rather than a team. gymnastics, running, figure skating, dance or diving, versus teams sports such as basketball or soccer.
  - Endurance sports (track and field/running, swimming)
  - Focus or belief that lower body weight will improve performance.
  - Training for a sport since childhood or being an elite athlete.
  - Low self-esteem; family dysfunction (including parents who live through the success of their child in sport); families history of eating disorders; chronic dieting; history of physical or sexual abuse; peer, family/cultural pressures to be thin
  - Trainers and coaches who focus on success and performance rather than on the athlete as a whole person.

HCP Considerations for Disordered Eating

- Rigid food rules may increase the likelihood of disordered eating
  - Consider how you talk about food
  - “Good/Bad”, “Avoid”
  - Consider mindful eating concepts
- Health versus weight
- Watch for signs of preoccupation with thinness above all else
- Excessive exercise

Key Points

- Nutrition advice for people with T1D performing regular exercise should:
  - Be individualized
  - Meet the nutritional demands of the sport
  - Include management of glycemia
  - Based on a meal and insulin adjustment plan
  - Address adequate hydration

GLYCEMIC MANAGEMENT

PER WINTERDIJK & EELCO DE KONING

Disclosures Eelco Koning

Geen (potentiële) belangenverstrengeling	
Voor bijeenkomst mogelijk relevante relaties	**Bedrijfsnamen**
•Geen	• • • • •

Session Objectives

Upon completion of this session, you will be better able to:

- Differentiate types of exercise, and the differences in their management
- Adjust insulin dose to prevent both hypoglycemia and severe glycemic variation
- Adjust carbohydrate intake to prevent both hypoglycemia and severe glycemic variation

Note: These are general guidelines/starting points for individual patient management

Before We Begin…

Let’s review
a clinical case!

Case Study: Adolescent Male Recreational Athlete

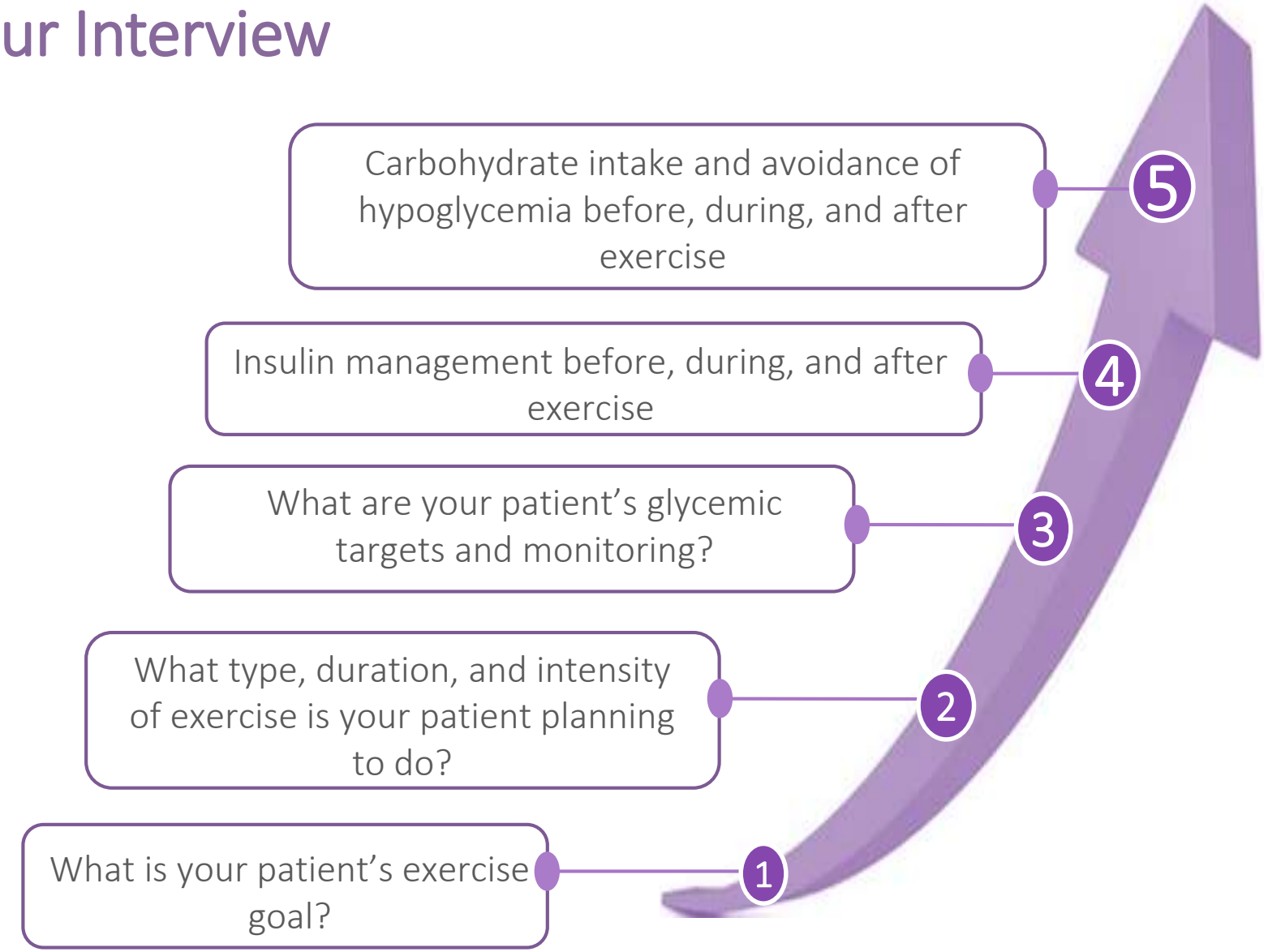
- 16-year-old male, 11th grader with type 1 diabetes since age 15,
  May 2015 (1+ year duration)
- At onset, presented with DKA and HbA_{1c} of 12% (108 mmol/mol) post- 20 lb (9 kg) weight loss
- Started pump therapy in Oct. 2014; HbA_{1c} was 6.5% (48 mmol/mol)
- Playing 2 sports (tennis and swimming)
- Follow-up appointment in July 2016
  - Current weight 181 lb (82 kg); height 71'' (180 cm)
  - HbA_{1c} 7.5% (58 mmol/mol); TDD 41 U; Basal 17 U (42%); Bolus 24 U
  - SMBG average 155 mg/dL (8.6 mmol/L), SD 51 on 2 test/day; CGM was prescribed
  - Basal was increased to 0.75, ICR 1:13, ISF 2.8 mg/dL with target 4.5-6.5

BMI, body mass index; CGM, continuous glucose monitoring; DKA, diabetic ketoacidosis; ICR, insulin:carb ratio; ISF, insulin senstitivity factor; SD, standard deviation; SMBG, self-monitored blood glucose; TDD, total daily dose

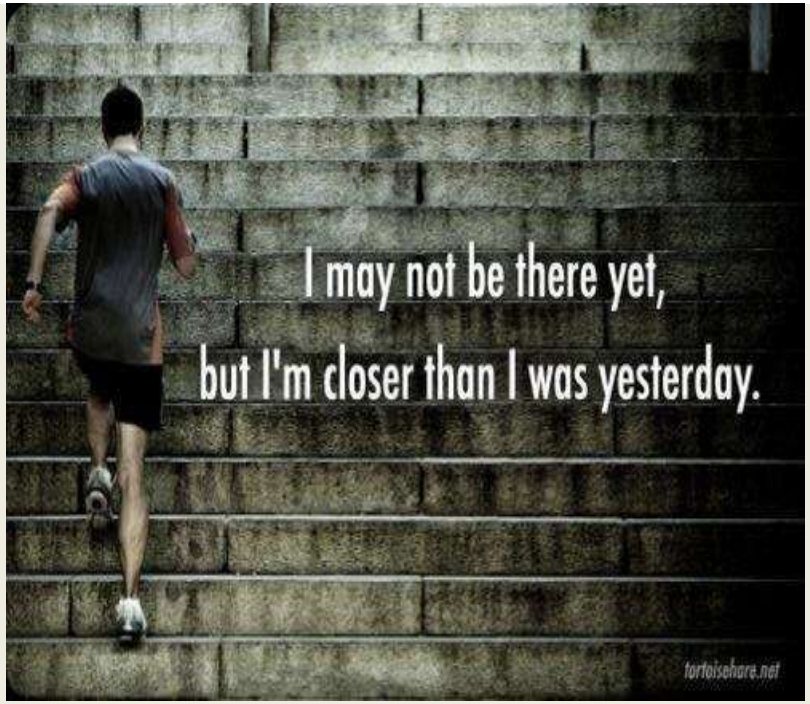
Adolescent Male Recreational Athlete: Issues

- In August 2016, joined the swim team and now has hypoglycemia while swimming (~90 min a day), in spite of suspending the pump 30 minutes before his practice at 2.30 pm
- Has decreased his basal from .75 to 0.55 U/hr in the hours before suspending and reduced his ICR to 1:16, but still goes low
- He wears his CGM every day*: Mean 126 mg/dL (7 mmol/L), SD 37
- Weight has decreased from 181 lb to 176 lb (82 kg to 80 kg)
- Wants advice on what to do

Planning Your Interview



Exercise Goals

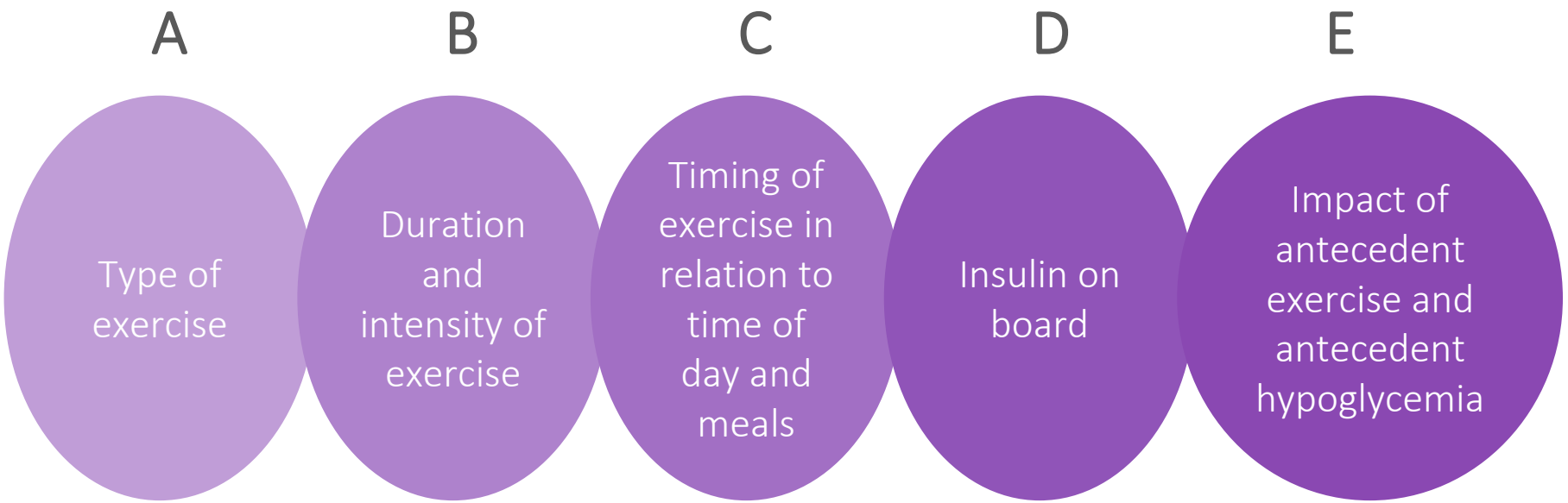


What is Your Patient's Exercise Goal?

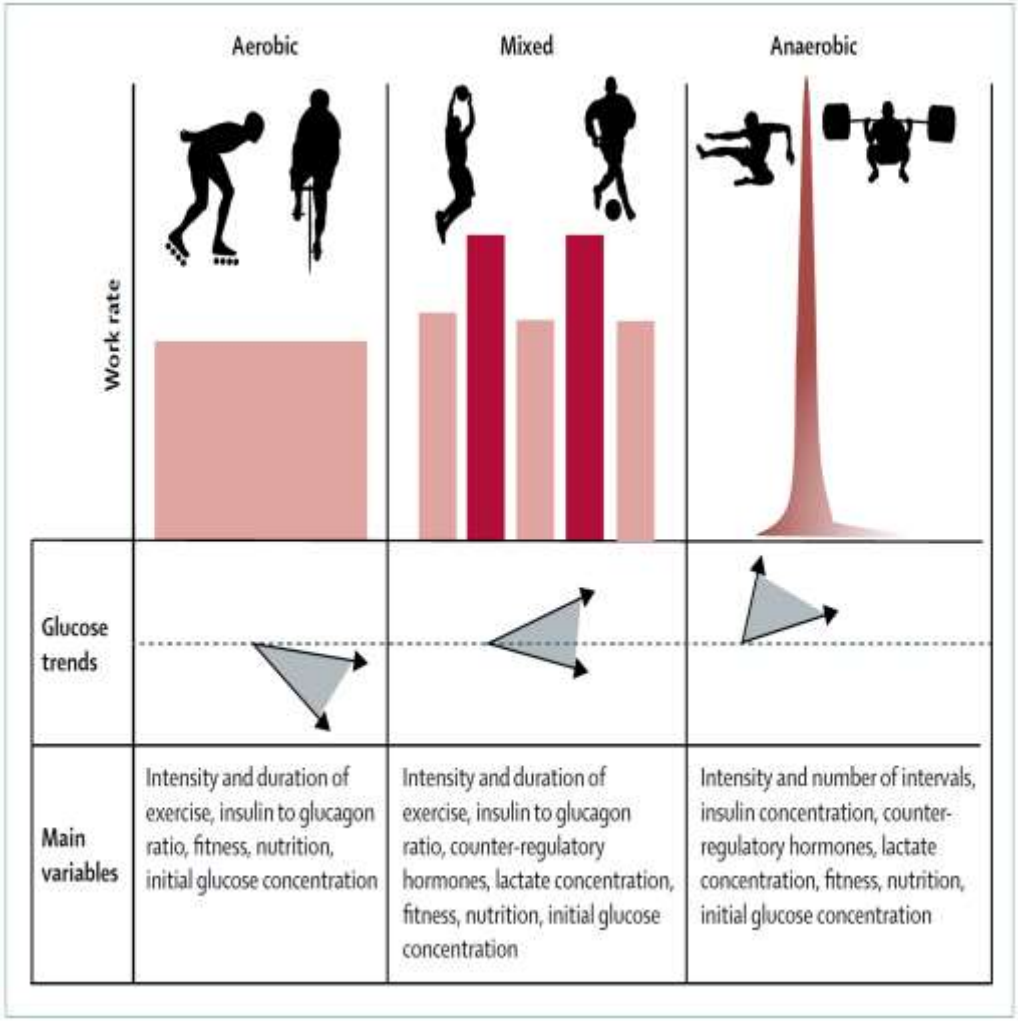
- Weight Management ✓
- Improvement of fitness ✓
- Enjoyment of sports ✓

Type, Duration, and Intensity of Exercise

5 Things to Consider



Types of Exercise and General Glucose Trends



Riddell, MC, *et al*. Lancet Diabetes Endocrinol. 2017 Jan 23. pii: S2213-8587(17)30014-1. doi: 10.1016/S2213-8587(17)30014-1

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Glycemic Targets

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Pre Exercise Glucose Levels

- Below target (<90 mg/dL/ <5.0 mmol/L)
    - Ingest 10–20 g rapid acting CHO
- Near target (90–124 mg/dL/ 5.0 - 7.0 mmol/L)
    - Ingest 10 g rapid acting CHO
    - Anaerobic exercise and high intensity interval training may be started without CHO intake
- At target (125–180 mg/dL/ 7.0 - 10.0 mmol/L)
    - Aerobic exercise can be started
    - Anaerobic exercise and high intensity interval training may be started, but levels may rise

Riddell, MC, *et al*. Lancet Diabetes Endocrinol. 2017 Jan 23. pii: S2213-8587(17)30014-1. doi: 10.1016/S2213-8587(17)30014-1

Pre Exercise Glucose Levels

- Slightly above target (181–270 mg/dL/ 10.0 - 15.0 mmol/L)
    - Aerobic exercise can be started.
    - Anaerobic exercise can be started, but glucose concentrations may rise.
- Above target (>270 mg/dL, >15.0 mmol/L)
    - Check blood ketones if hyperglycemia is unexplained
    - If modestly elevated (up to 1·4 mmol/L), exercise should be restricted to a light intensity for only a brief duration (<30 min)
    - A small insulin corrective dose might be needed before exercise
    - If blood ketones are ≥1·5 mmol/L, exercise is contraindicated

Riddell, MC, *et al*. Lancet Diabetes Endocrinol. 2017 Jan 23. pii: S2213-8587(17)30014-1. doi: 10.1016/S2213-8587(17)30014-1

Tools Available for Use

Your glycemic management toolkit

1. Use of a glucose meter / testing instrument
2. Pre- and post-exercise insulin
3. Basal insulin adjustment
4. Carbohydrate intake
5. Maximum sprint

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Glucose Management

1. The best way to avoid hypoglycemia is to regularly monitor/check glucose level before, during, and after exercise

2. Patients with type 1 diabetes should not exercise if their glucose meter (or CGM) and strips are not readily available

Starting Blood Glucose Before Exercise

Blood glucose concentrations	Recommendations (rule of thumb)*
<5.0 mmol/L#	▪ Ingest 10–20 g of glucose before exercise ▪ Delay exercise until blood glucose >90 mg/dL
5 – 8 mmol/L#	▪ Ingest 10 g of glucose ▪ Exercise can be started
8 – 15 mmol/L#	▪ Low intensity exercise can be started
>15 mmol/L	▪ Check blood ketones and perform low intensity exercise, or give small corrective dose of insulin ▪ Low intensity exercise may be okay if blood ketones are <1.5 mmol/L, or <2+ urine ketones; consider small corrective dose of insulin

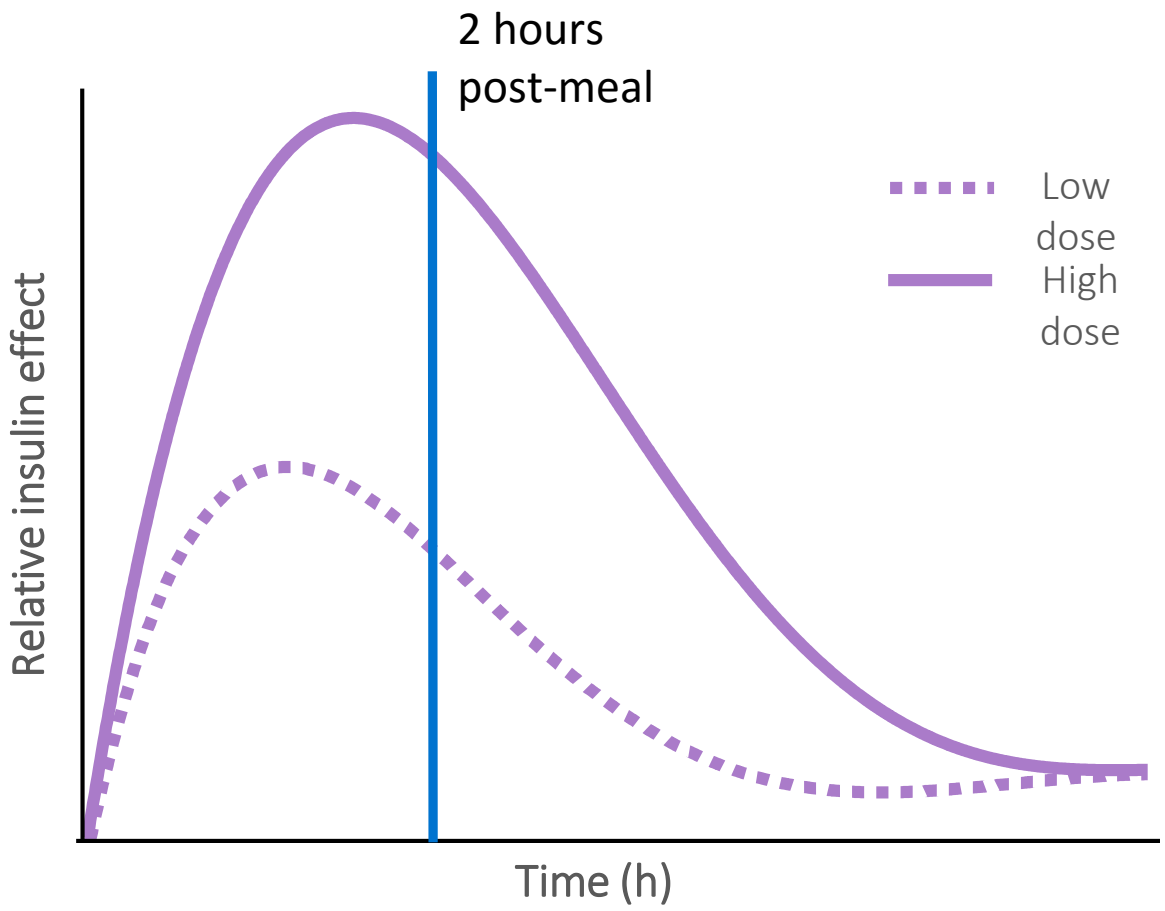
**People with type 1 diabetes should aim to start exercise with blood glucose between 90 and 144 mg/dL*

 # 90 mg/dL = 5mmol/L; 144 mg/dL = 8mmol/L; 270 mg/dL = 15 mmol/L

Based on expert opinion. http://www.londonmedical.co.uk/news-and-events/2161/.

Insulin Management

Bolus Rapid-Acting Insulin Analogue Effect at Low Dose and High Dose



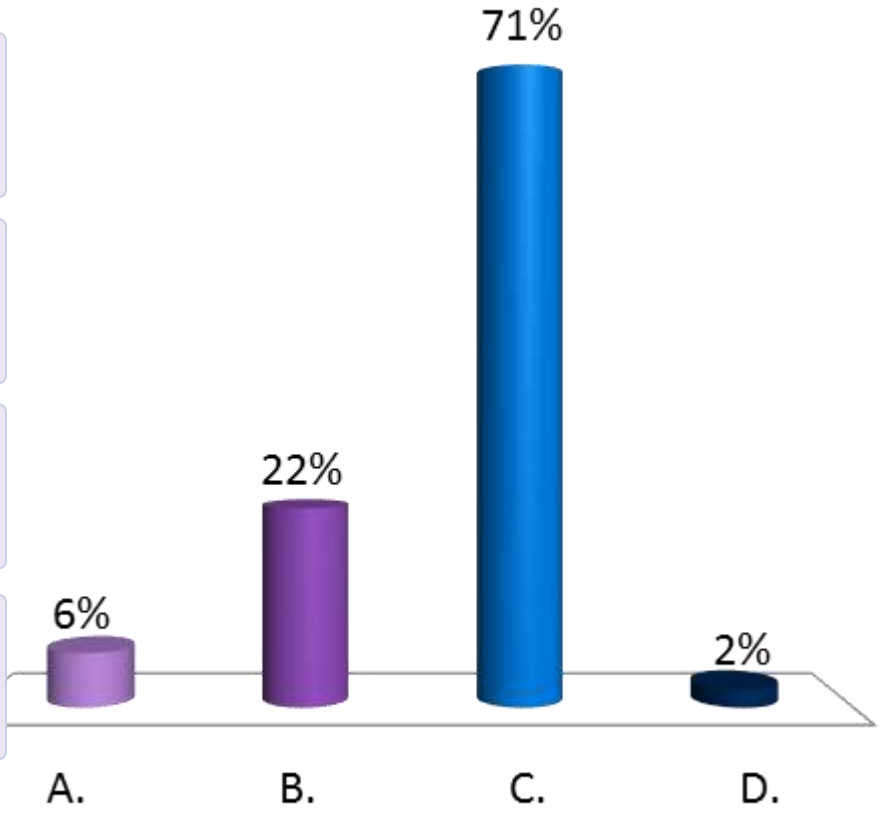
If you are taking a bolus insulin dose less than 2 hours before aerobic exercise, by what initial percentage should the bolus insulin dose be reduced ?

A 20%

B 30%

C 50%

D 60%



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If you are taking a bolus insulin dose less than 2 hours before aerobic exercise, by what initial percentage should the bolus insulin dose be reduced ?

A 20%

B 30%

C 50%

D 60%

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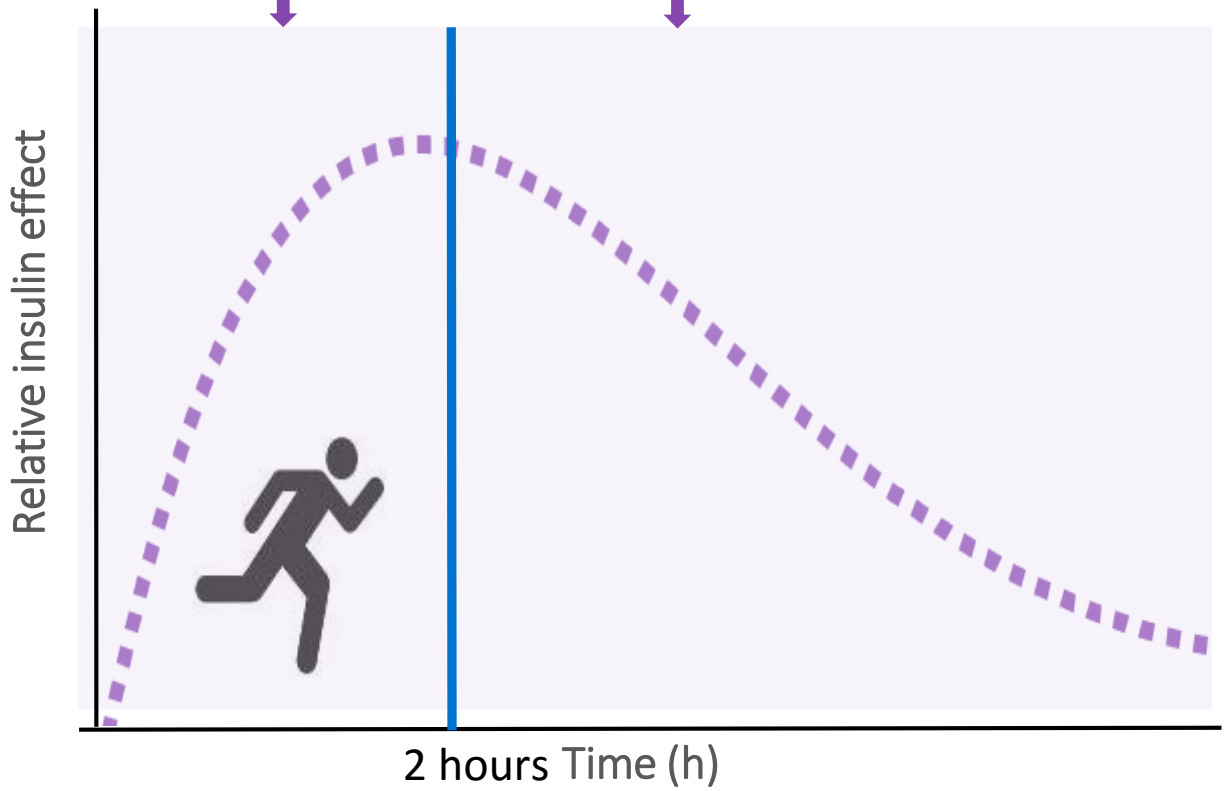
Bolus Insulin Effect

- Reduce pre-exercise insulin dose
- Consume carbohydrates with low glycemic index

- If blood glucose is running low, must consume carbohydrates



Nosek L et al. *Diabetes Obes Metab* 2013;15:77-83

Bolus Insulin Dose Adjustment Before Aerobic Exercise

	Recommendations
Consider the amount of insulin on board	
Exercise ≤120 mins after bolus insulin dose	▪ Reduce pre-exercise insulin dose by 25-75% *[1–3]and consume carbohydrates with a low glycaemic index at mealtime[4,5]
Exercise >120 mins after bolus insulin dose	▪ If blood glucose is running low, must consume carbohydrates

**Not beneficial for exercise in the late post-prandial period.*

For patients who use exercise for weight management, reduce the insulin dose to control carbohydrate consumption during and after exercise

1. Mauvais-Jarvis et al. 2003. *Diabetes Care 26(4):1316-7*
2. Hernandez et al. 2000. *Medicine & Science in Sports & Exercise 32(5):904-10*
3. Rabasa-Lhoret et al. 2001. *Diabetes Care 24(4):625-30*
4. West et al. 2009. [Abstract]. *Diabetic Medicine 26:60, 2009*
5. DirecNet Study Group et al. 2006. *Diabetes Care 29(10):2200-4*

Basal Insulin Dose Adjustment Before Aerobic Exercise

Patients on MDI

- Basal insulin dose adjustment is
  not routinely recommended
- If on BID basal, one could consider reducing one or both of the basal doses by 20%

Patients on insulin pumps

- Basal insulin dose reduction 60-80% may be useful for exercise over 45 to 60 minutes
- Dose could be reduced up to 90 minutes before exercise

Riddell, MC, *et al*. Lancet Diabetes Endocrinol. 2017 Jan 23. pii: S2213-8587(17)30014-1. doi: 10.1016/S2213-8587(17)30014-1

Basal Insulin Dose Adjustment After Exercise: MDI vs CSII

MDI

- Reduce night time dose by 20%
- Encourage increased carbohydrate consumption
  to prevent nocturnal hypoglycemia
- Test blood glucose during the night

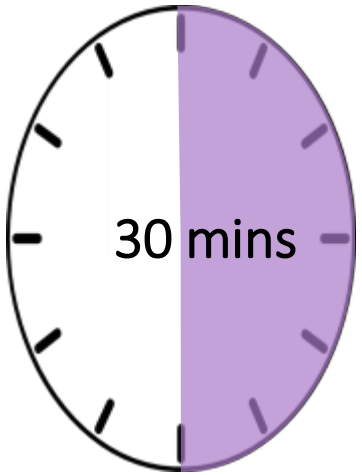
Pump

- Reduce insulin dose by 20% to 3 am
- Encourage increased carbohydrate consumption
- Test blood glucose during the night

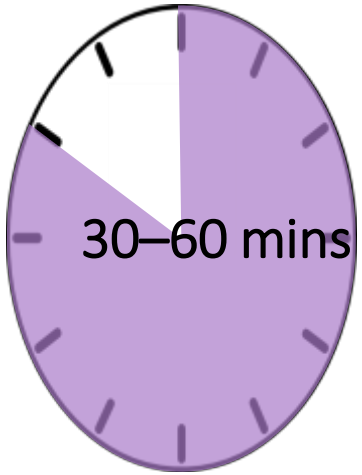
Riddell, MC, *et al*. Lancet Diabetes Endocrinol. 2017 Jan 23. pii: S2213-8587(17)30014-1. doi: 10.1016/S2213-8587(17)30014-1

Carbohydrate Intake to Prevent Hypoglycemia

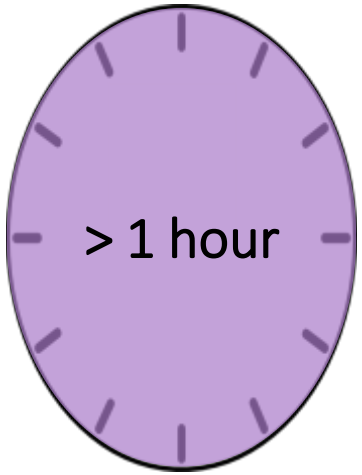
Carbohydrate Intake During Exercise Performed Under Near Basal Insulinemic Conditions



- Carbohydrates may not be needed, unless blood glucose is dropping



- Carbohydrates may be needed for very strenuous activity or no insulin adjustment



- Carbohydrates may be needed
for fuel (30–60 g/hr)

Thomas DT , *et al. J Acad Nutr Diet* 2016; 116 (3): 501-28; Riddell, MC, *et al*. Lancet Diabetes Endocrinol. 2017 Jan 23. pii: S2213-8587(17)30014-1. doi: 10.1016/S2213-8587(17)30014-1

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Carbohydrate Intake During Exercise Performed Under Hyperinsulinemic Conditions

- For short (30 mins-1 hour) or more prolonged (>1 hour) exercise, consume 15–30 g of carbohydrates per 30 minutes of exercise
  - Consider carbohydrates with a high glycaemic index

** The glycemic index of carbohydrates affects their efficacy at preventing hypoglycemia*

Simpler forms of carbohydrate, such as glucose, can be ingested regularly during exercise in an accessible form[1-7]

1. Francescato et al. 2008 *Metabolism: Clinical & Experimental 53(9):1126-30;*
2. Francescato et al. 2008. *International Journal of Sports Medicine 29(9):706-12;*
3. *Mauvais-Jarvis et al. 2003. Diabetes Care 26(4):1316-7;*
4. Ramires et al. 1997. *Journal of Applied Physiology 83(2):608-14;*
5. Riddell et al. 2000. *Journal of Applied Physiology 88(4):1239-46;*
6. Tamis-Jortberg et al. 1996. *Diabetes Educator 22(5):471-87;*
7. West et al. 2011. *Medicine & Science in Sports & Exercise 43(2):204-10.*

Carbohydrate Intake During Exercise: Key Takeaways

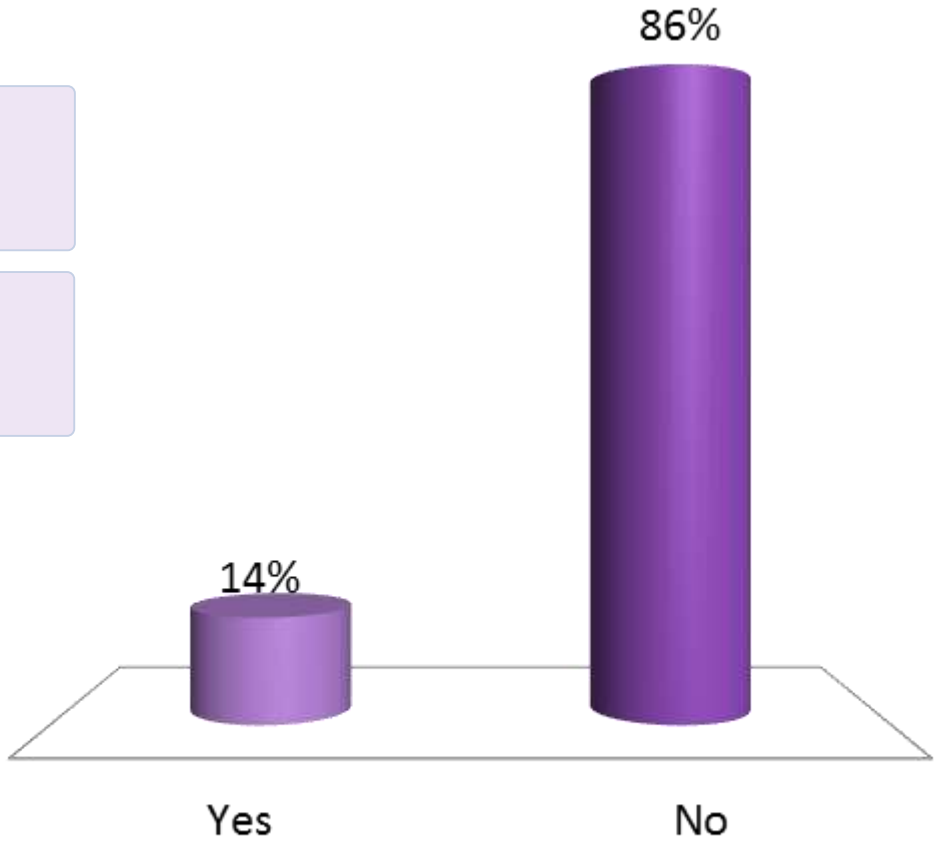
1. The mainstay of management remains balance of insulin and carbohydrates
2. Carbohydrate consumption during exercise could is beneficial for endurance performance
3. It is important not to over-replace; this may result in hyperglycemia

Carbohydrate intake is more important in patients on multiple daily injections of insulin, as lowering the amount of insulin in patients on continuous subcutaneous insulin infusion may be difficult .

Should carbohydrates always be consumed within 1 hour of mild exercise?

A Yes

B No



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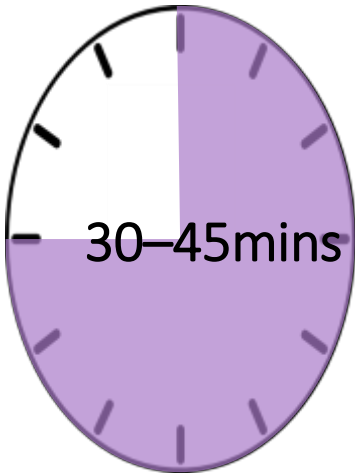
Should carbohydrates always be consumed within 1 hour of mild exercise?

A Yes

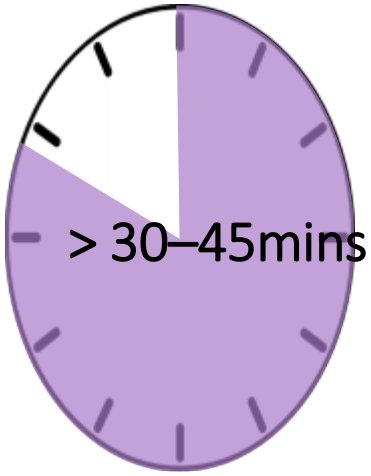
B No

Carbohydrate Intake Within 1 Hour After Exercise



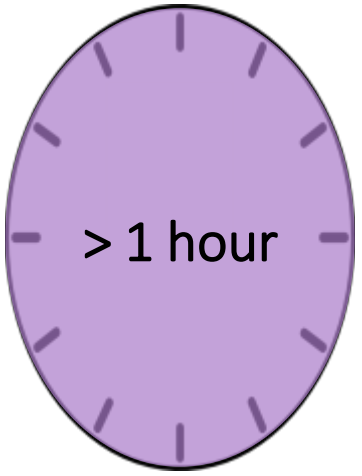
Mild exercise

- Carbohydrates may not be needed



Intense (short, high impact) exercise

- Replenish carbohydrates (15–30 g)



Prolonged moderate to intense exercise

- Replenish carbohydrates (15–30 g/hr)

The post-exercise meal should be consumed preferably within 1 hr after exercise

Hypoglycemia Prevention Using Short Duration Sprinting

- Intermittent high intensity exercise (several high intensity exercise bouts lasting ~4–5 seconds), to maintain blood glucose while reducing carbohydrate intake
- Used to counter the rapid fall in glycemia due to moderate-intensity exercise in individuals with type 1 diabetes
  - Decreases the risk of early post-exercise hypoglycemia
  - Efficacy of sprinting is likely to decrease in overinsulinized individuals
- Note: Repeated circuits of high-intensity exercise, especially when mixed with aerobic exercise, could result in significant reductions in blood glucose

1. Bussau et al. 2006. *Diabetes Care 29:601-606;*
2. Bussau et al. 2007. *Diabetologia 50:1815-1818.*

AVOIDANCE OF HYPOGLYCEMIA

Overview

BEFORE EXERCISE

- People are more likely to experience hypoglycemia during exercise after a recent episode of hypoglycemia
- Patients need to address mild or moderate hypoglycemia before exercising, and make adjustments accordingly

AFTER EXERCISE

- Hypoglycemia may occur several hours after exercise due to replenishment of muscle and liver glycogen stores
- Exercise in the afternoon or evening may lead to nocturnal hypoglycemia[1,2,3]
- Post-exercise hypoglycemia is more pronounced if exercise is repeated on subsequent days

1. Tsalikian et al. 2005. *J Pediatr 147:528-34;*
2. Briscoe et al. 2007. *Appl Physiol Nutr Metab 32:576-82;*
3. Campbell et al. 2014. *Diabetes Care 37):1845-53.*

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Exercise After Hypoglycemia

	Recommendations (rule of thumb)
Self-treated hypoglycemia within 1 hour of planned activity	▪ In case of exercise, treat hypoglycemia to stabilize blood glucose before activity ▪ If glucose level increases, it is okay to exercise; monitoring is necessary ▪ May need to retreat as hypoglycemia is more likely to occur
Severe hypoglycaemia within 24 hours of planned activity	▪ Ideally, exercise should not be undertaken ▪ Patients should not exercise, and alert others of the potential for hypoglycaemia
Hypoglycaemia during exercise	▪ Discontinue the activity and treat hypoglycaemia

Note: People with type 1 diabetes should not exercise within 24 hours of severe hypoglycemia

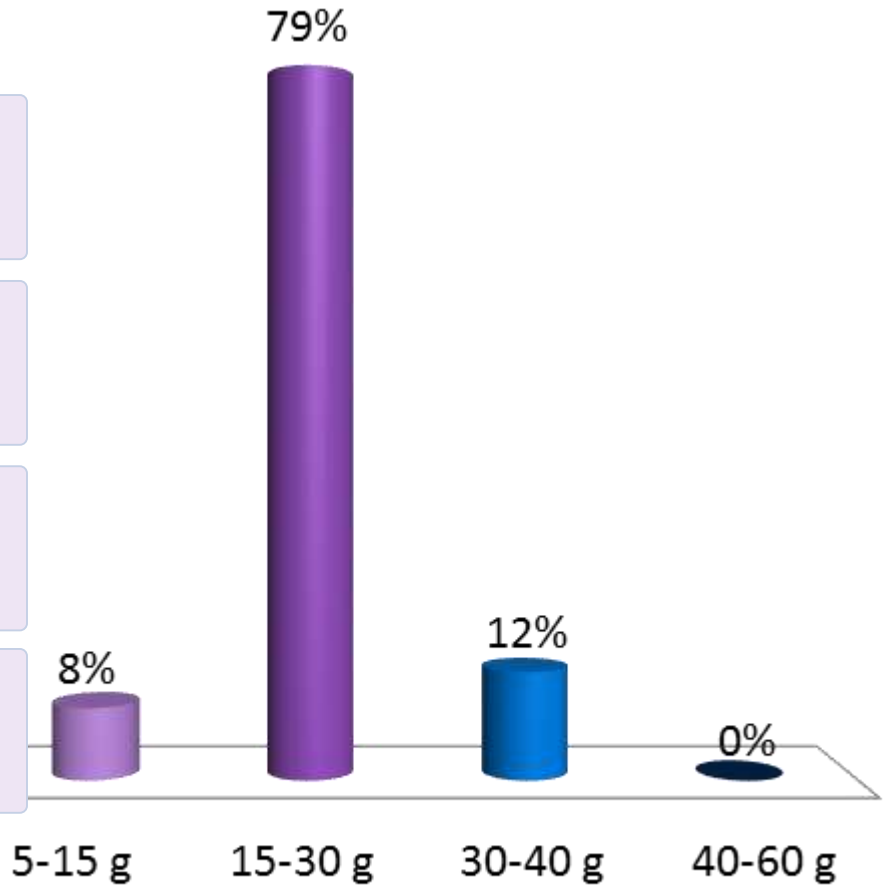
How much carbohydrate would you recommend within the first hour after exercise, to avoid post-exercise hypoglycemia?

A 5-15 g

B 15-30 g

C 30-40 g

D 40-60 g



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How much carbohydrate would you recommend within the first hour after exercise, to avoid hypoglycemia?

A 5-15 g

B 15-30 g

C 30-40 g

D 40-60 g

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Avoidance of Hypoglycemia After Exercise

- 15–30 g of carbohydrates are recommended for the first hour of recovery (may or may not require bolus insulin)
- If exercise results in severe glycogen depletion, a far larger daily carbohydrate intake is recommended to:
  1. Normalize insulin sensitivity
  2. Replenish muscle/hepatic glycogen stores
- Consider adding protein (20–30 g)

Note: It is important that individuals are aware of the need for adequate carbohydrate replacement following exercise, and should be advised regarding the risk of nocturnal hypoglycemia

Based on expert opinion.
Adapted from Thomas DT , *et al. J Acad Nutr Diet* 2016; 116 (3): 501-28

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Avoidance of Nocturnal Hypoglycemia: Overview

- Nocturnal hypoglycemia may result from:
  1. Impaired counter regulation
  2. Glycogen levels not being replaced
  3. Bolus insulin following high intensity exercise in late afternoon/evening*
- Reduction of basal insulin dose by ~20% in the first 12 hours after exercise reduces the risk of hypoglycemia[#1,2,3]
- For patients on multiple daily insulin injections, reduction of pre-exercise prandial insulin dose combined with basal insulin reduction markedly (by 20%) reduces the risk of nocturnal hypoglycemia[3]

** Cool down post high intensity exercise for 15–20 mins reduces the need for insulin to correct post-exercise hyperglycemia*

 # Reduction of basal insulin dose may not be possible with long-acting and ultra-long-acting insulins

1. Taplin et al. 2010. *Journal of Pediatrics 157(5):784-8 e1;*
2. Perry and Gallen 2009. *Practical Diabetes International 26 (3) (pp 116-123);*
3. Campbell et al. 2015. *BMJ Open Diabetes Research and Care 3:e000085.*

Avoidance of Nocturnal Hypoglycemia: Overview (Cont'd)

- Hypoglycemic unawareness is of special concern, and requires specific attention[2]
- Hypoglycemia is less likely to be observed and treated in those who sleep alone, and is potentially life-threatening[3]
- Endurance exercise (> 45 minutes) in the morning is less likely to result in hypoglycemia than endurance exercise later on in the day
- Blood glucose levels need to be measured during the night
- Automatic suspension of insulin delivery may reduce the duration and severity of exercise-induced hypoglycemia without rebound hyperglycemia[1]

1. Garg et al. 2012. *Diabetes Technol Ther. Mar; 14(3): 205-9;*
2. Maran et al. 2010. *Diabetes Technology & Therapeutics 12(10):763-8;*
3. Tattersall and Gill . 1991. *Diabetic Medicine 8(1):49-58.*

Avoidance of Nocturnal Hypoglycemia: Recommendations for Patients

1. Set alarms to check blood glucose levels during the night
2. Advise household members on signs of severe hypoglycemia, and on appropriate use of glucose gels or glucagon
3. Avoid alcohol following exercise*[1,2]
4. We suggest that continuous glucose monitoring (CGM) should be used, with the benefits of:
   - Alerts in case of hypoglycemia
   - No alerts if no hypoglycemia is detected

** The risk of hypoglycemia is minimal if a moderate intake of alcohol is combined with carbohydrate intake*

1. Cheyne et al. 2004. *Diabetic Medicine 21(3):230-7;*
2. Richardson et al. 2005. [Report]. *Diabetes Care July* 28:1801-1802.

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CLINICAL CASE

Case Study: Adolescent Male Recreational Athlete

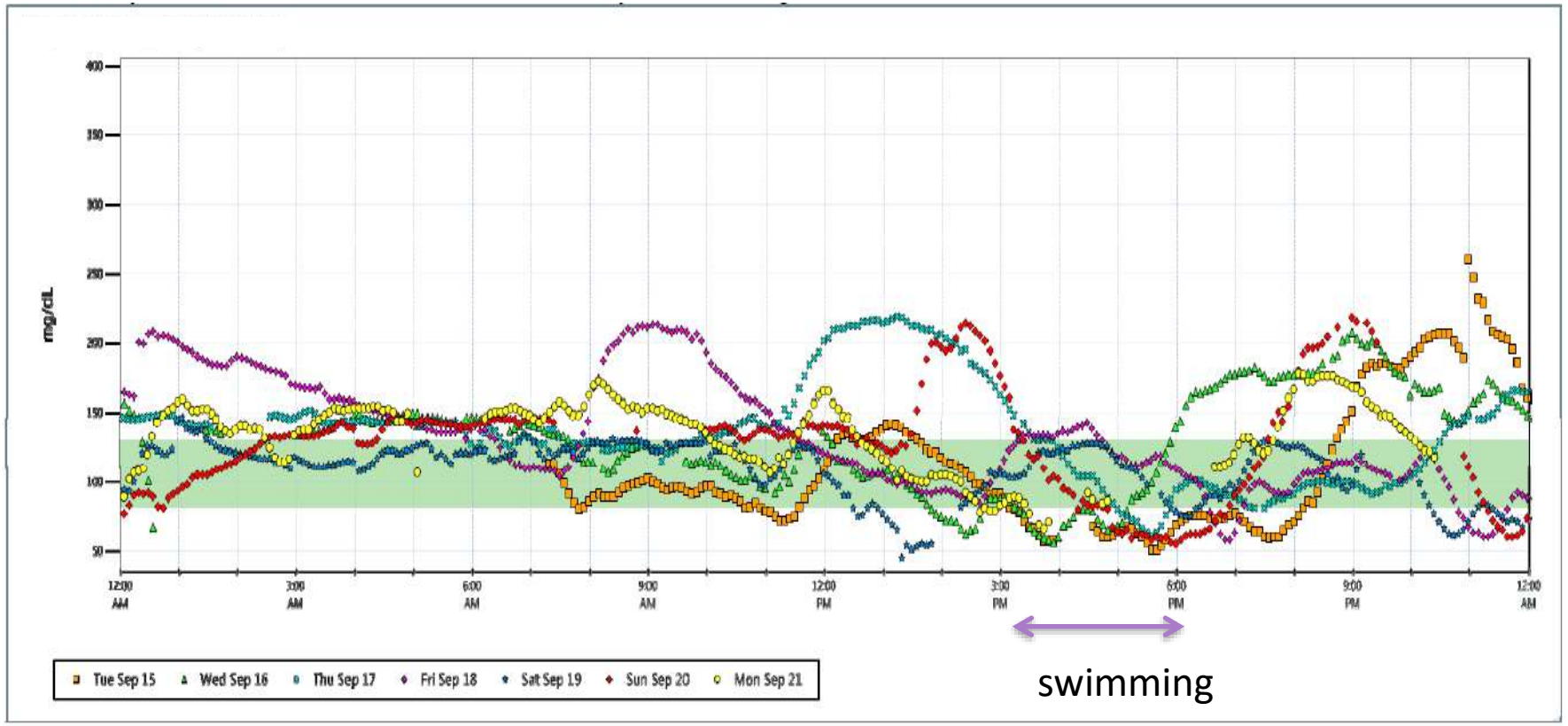
- 16-year-old male, 11th grader with type 1 diabetes since age 15,
  May 2015 (1+ year duration)
- At onset, presented with DKA and HbA_{1c} of 12% (108 mmol/mol) post- 20 lb (9 kg) weight loss
- Started pump therapy in Oct. 2014; HbA_{1c} was 6.5% (48 mmol/mol)
- Playing 2 sports (tennis and swimming)
- Follow-up appointment in July 2016
  - Current weight 181 lbs (82 kg); height 71'' (180 cm)
  - HbA_{1c} 7.5% (58 mmol/mol) TDD 41 U; Basal 17 U (42%); Bolus 24 U
  - SMBG average 155 mg/dL (8.6 mmol/L), SD 51 on 2 test/day; CGM was prescribed
  - Basal was increased to 0.75, ICR 1:13, ISF 2.8 mg/dL with target 4.5-6.5

BMI, body mass index; CGM, continuous glucose monitoring; DKA, diabetic ketoacidosis; ICR, insulin:carb ratio; ISF, insulin senstitivity factor; SD, standard deviation; SMBG, self-monitored blood glucose; TDD, total daily dose

Adolescent Male Recreational Athlete: Issues

- In August 2016, joined the swim team and now has hypoglycemia while swimming (3 hours a day), in spite of suspending the pump 30 minutes before his practice at 2.30 pm
- Has decreased his basal to 0.55 U/hr and reduced his ICR to 1:16, but still goes low
- He wears his CGM every day: Mean 126 mg/dL (7 mmol/L), SD 37
- Weight has decreased from 181 lb to 176 lb (82 kg to 80 kg)
- Wants advice on what to do

Daily Trends: 9/15/16 – 9/21/16



What Are the Issues?

1. Frequently hypoglycemic with exercise
2. Hyperglycemic from 6pm - 9pm
3. But hypoglycemic from 9pm - 12pm

Possible solutions:

- Reduce ICR further to 1:16 with lunch
- Reduce basal insulin 1hr before exercise to 0.45 U/hr and possibly lower
- Resume normal basal rate of 0.75 U/hr after exercise
- Review carbohydrate intake after exercise

Limitations of Guidelines to Avoid Hypoglycemia with Exercise

1. These guidelines discussed in this presentation are a starting point for advising patients
2. There are various strategies that can be used, and the applicability of these will depend on:
   - The patient's goals and fitness
   - The duration of the activity
3. The physician should adapt his/her approach following feedback

THANK YOU!

Lunchpauze

- De pauze vindt plaats in de Molenhoek.
- De workshops starten om 14.00 uur in de workshopzalen (zie badge)
- Mocht u vragen hebben, dan kunt u bij de balie van Health Investment terecht

Break-out sessies

- A. Pomp en technologie - zaal: Princeville
- B. De recreatieve, competitieve en elite atleet - zaal: Haagsche schouw
- C. De kind- en jeugdvolwassenatleet - zaal: Kinderdijk
- D. Sportvoeding - zaal: de Witte

Paneldiscussie (Q&A)

Health Investment

Afsluiting en evaluatie