IDROTT OCH TYP 1 DIABETES

Foto: Stafettvasan

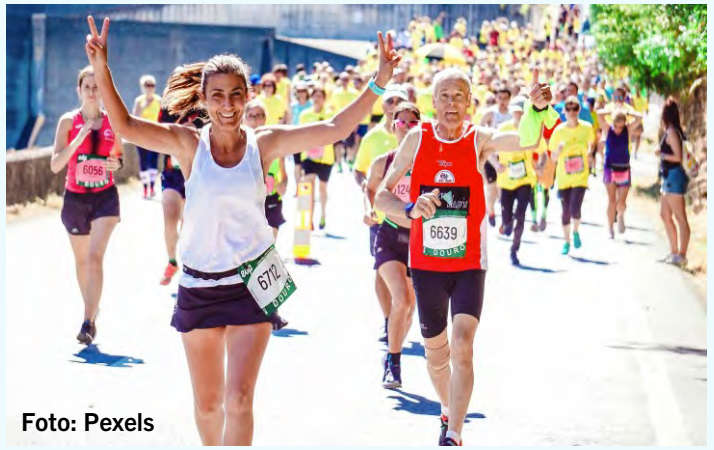
Foto: Pexels

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UTMANINGAR – LÅNGVARIG FYSISK AKTIVITET


Foto: Gaby Lopez, Pexels


Foto: Vasaloppet


Foto: Pixabay

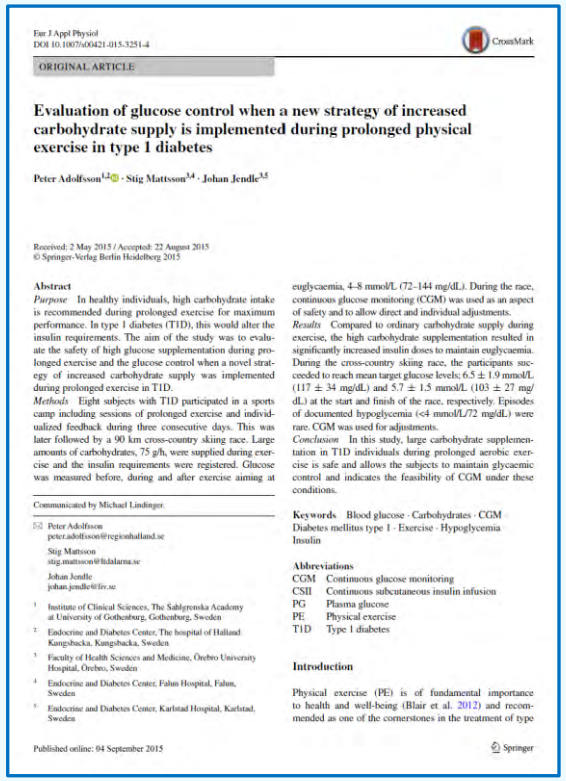
Stig Mattsson, Dietist, PhD – April 2026

DOKTORAND ÖREBRO UNIVERSITET

2013-2025

2013-2025 **Strategies for Glycemic Control in Type 1 Diabetes Before, During, and After Prolonged Exercise**

2015



Eur J Appl Physiol
DOI 10.1007/s00421-015-3251-4

ORIGINAL ARTICLE

Evaluation of glucose control when a new strategy of increased carbohydrate supply is implemented during prolonged physical exercise in type 1 diabetes

Peter Adolfsson[1,2] · Stig Mattsson[3,4] · Johan Jendle[3,5]

Received: 2 May 2015 / Accepted: 22 August 2015
© Springer-Verlag Berlin Heidelberg 2015

Abstract
Purpose In healthy individuals, high carbohydrate intake is recommended during prolonged exercise for maximum performance. In type 1 diabetes (T1D), this would alter the insulin requirements. The aim of the study was to evaluate the safety of high glucose supplementation during prolonged exercise and the glucose control when a novel strategy of increased carbohydrate supply was implemented during prolonged exercise in T1D.
Methods Eight subjects with T1D participated in a sports camp including sessions of prolonged exercise and individualized feedback during three consecutive days. This was later followed by a 90 km cross-country skiing race. Large amounts of carbohydrates, 75 g/h, were supplied during exercise and the insulin requirements were registered. Glucose was measured before, during and after exercise aiming at euglycaemia, 4–8 mmol/L (72–144 mg/dL). During the race, continuous glucose monitoring (CGM) was used as an aspect of safety and to allow direct and individual adjustments.
Results Compared to ordinary carbohydrate supply during exercise, the high carbohydrate supplementation resulted in significantly increased insulin doses to maintain euglycaemia. During the cross-country skiing race, the participants succeeded to reach mean target glucose levels; 6.5 ± 1.9 mmol/L (117 ± 34 mg/dL) and 5.7 ± 1.5 mmol/L (103 ± 27 mg/dL) at the start and finish of the race, respectively. Episodes of documented hypoglycemia (<4 mmol/L/72 mg/dL) were rare. CGM was used for adjustments.
Conclusion In this study, large carbohydrate supplementation in T1D individuals during prolonged aerobic exercise and the insulin requirements were registered. Glucose control and indicates the feasibility of CGM under these conditions.

Communicated by Michael Lindinger.

Peter Adolfsson
peter.adolfsson@regionhalland.se
Stig Mattsson
stig.mattsson@hdalarna.se
Johan Jendle
johan.jendle@liv.se

[1] Institute of Clinical Sciences, The Sahlgrenska Academy at University of Gothenburg, Gothenburg, Sweden
[2] Endocrine and Diabetes Center, The hospital of Halland Kungsbacka, Kungsbacka, Sweden
[3] Faculty of Health Sciences and Medicine, Örebro University Hospital, Örebro, Sweden
[4] Endocrine and Diabetes Center, Falun Hospital, Falun, Sweden
[5] Endocrine and Diabetes Center, Karlstad Hospital, Karlstad, Sweden

Published online: 04 September 2015

Keywords Blood glucose · Carbohydrates · CGM · Diabetes mellitus type 1 · Exercise · Hypoglycemia · Insulin

Abbreviations
CGM Continuous glucose monitoring
CSII Continuous subcutaneous insulin infusion
PG Plasma glucose
PE Physical exercise
T1D Type 1 diabetes

Introduction
Physical exercise (PE) is of fundamental importance to health and well-being (Blair et al. 2012) and recommended as one of the cornerstones in the treatment of type

Springer

2019

frontiers in Endocrinology

CLINICAL TRIAL
published: 21 August 2019
doi: 10.3389/fendo.2019.00571

Carbohydrate Loading Followed by High Carbohydrate Intake During Prolonged Physical Exercise and Its Impact on Glucose Control in Individuals With Diabetes Type 1—An Exploratory Study

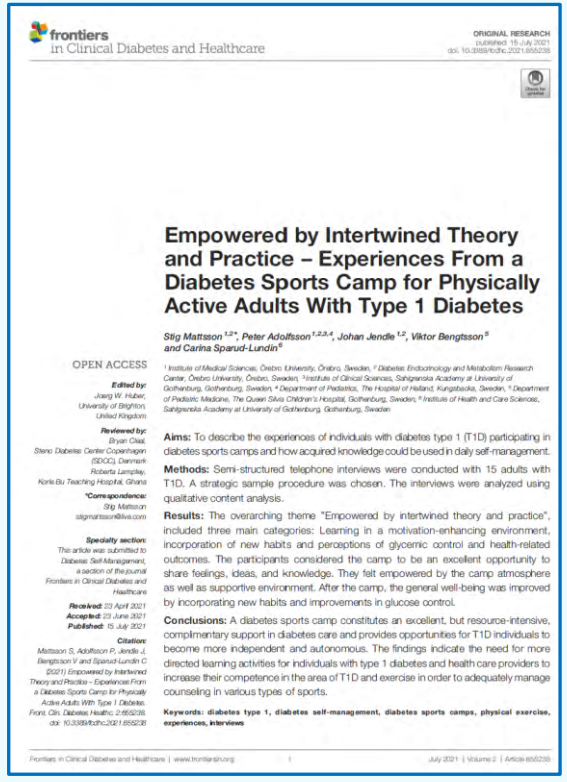
Stig Mattsson†, Johan Jendle† and Peter Adolfsson†*

OPEN ACCESS

Background: Prolonged physical exercise (PE) is a challenge in type 1 diabetes with an increased incidence of both hypoglycemia and hyperglycemia.
Purpose: To evaluate the impact of two consecutive days of carbohydrate (CHO) loading, followed by high intermittent CHO-intake during prolonged PE, facilitated by a proactive use of Real-Time Continuous Glucose Monitoring (rtCGM), on glucose control in individuals with type 1 diabetes.
Methods: Ten physically active individuals with type 1 diabetes were invited to participate in a 3-day long sports camp with the objective to evaluate CHO-loading and high intermittent CHO-intake during prolonged PE. 1.5 months later the same procedure was evaluated in relation to a 90 km cross-country skiing race (Vasaloppet). Participants were instructed to act proactively using rtCGM with predictive alerts to maintain sensor glucose values within target range, defined as 72–180 mg/dl (4–10 mmol/l).
Results: Mean glucose values during CHO-loading were: day 1; 140.4 ± 45.0 mg/dl (7.8 ± 2.5 mmol/l) and day 2; 120.6 ± 41.4 mg/dl (6.7 ± 2.3 mmol/l). Mean sensor glucose at start of PE was 126.0 ± 25.2 mg/dl (7.0 ± 1.4 mmol/l) and throughout PE 127.8 ± 25.2 mg/dl (7.1 ± 1.4 mmol/l). Percentage of time spent in range (TIR) respective time spent in hypoglycemia was: CHO-loading 74.7/10.4% and during PE 94.3/0.6%.
Conclusions: High intermittent CHO-intake during prolonged PE combined with proactive use of rtCGM is associated with good glycemic control during prolonged exercise in individuals with diabetes type 1. However, the time spent in hypoglycemia during the 2-days of CHO-loading was 10.4% and therefore a lower insulin dose might be suggested to reduce the time spent in hypoglycemia.
Clinical Trial Registration: www.ClinicalTrials.gov, identifier NCT03722225

Keywords: blood glucose, carbohydrates, continuous glucose monitoring, insulin, physical activity, time in range, type 1 diabetes

2021



frontiers in Clinical Diabetes and Healthcare

ORIGINAL RESEARCH
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Empowered by Intertwined Theory and Practice – Experiences From a Diabetes Sports Camp for Physically Active Adults With Type 1 Diabetes

Stig Mattsson[1,2], Peter Adolfsson[1,2,3,4], Johan Jendle[1,2], Viktor Bengtsson[5] and Carina Sparud-Lundin[6]*

OPEN ACCESS

Aims: To describe the experiences of individuals with diabetes type 1 (T1D) participating in diabetes sports camps and how acquired knowledge could be used in daily self-management.
Methods: Semi-structured telephone interviews were conducted with 15 adults with T1D. A strategic sample procedure was chosen. The interviews were analyzed using qualitative content analysis.
Results: The overarching theme "Empowered by intertwined theory and practice", included three main categories: Learning in a motivation-enhancing environment, incorporation of new habits and perceptions of glycemic control and health-related outcomes. The participants considered the camp to be an excellent opportunity to share feelings, ideas, and knowledge. They felt empowered by the camp atmosphere as well as supportive environment. After the camp, the general well-being was improved by incorporating new habits and improvements in glucose control.
Conclusions: A diabetes sports camp constitutes an excellent, but resource-intensive, complimentary support in diabetes care and provides opportunities for T1D individuals to become more independent and autonomous. The findings indicate the need for more directed learning activities for individuals with type 1 diabetes and health care providers to increase their competence in the area of T1D and exercise in order to adequately manage counseling in various types of sports.

Keywords: diabetes type 1, diabetes self-management, diabetes sports camps, physical exercise, experiences, interviews

2025

JOURNAL OF THE INTERNATIONAL SOCIETY OF SPORTS NUTRITION
2025, VOL. 22, NO. 1, 2494839
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Taylor & Francis

OPEN ACCESS

Impact of carbohydrate timing on glucose metabolism and substrate oxidation following high-intensity evening aerobic exercise in athletes: a randomized controlled study

Stig Mattsson, Fredrik Edin, Jonny Trinh, Peter Adolfsson, Johan Jendle and Stefan Pettersson

[a]Örebro University, School of Medicine and Health, Institute of Medical Sciences, Örebro, Sweden; [b]Örebro University, Diabetes Endocrinology and Metabolism Research Center, Örebro, Sweden; [c]University of Gothenburg, Department of Food and Nutrition, and Sport Science, Centre for Health and Performance, Gothenburg, Sweden; [d]Sahlgrenska Academy at University of Gothenburg, Institute of Clinical Sciences, Gothenburg, Sweden

ABSTRACT
Objective: The study aimed to investigate the impact of nutrient timing in relation to evening exercise. Specifically, it examined the effects of pre- or post-exercise carbohydrate (CHO) ingestion on glucose metabolism, glucose regulation, and overall substrate oxidation in well-trained athletes during and after physical exercise (PE), spanning the nocturnal period and the subsequent morning.
Methods: Ten male endurance cyclists participated in the study. The initial assessments included body composition measurements and an incremental cycle test to determine maximal oxygen uptake (VO_2 max) and maximum power output (Wmax). Following this, participants underwent a control (rest previous day) oral glucose tolerance test (OGTT) and a familiarization exercise trial that had two objectives: (1) to establish the appropriate amount of CHO to use in the pre- or post-exercise drink during the experimental trials, and (2) to familiarize participants with the equipment and study protocol. In the three days prior to both the control and experimental trials, participants followed a standardized, individualized diet designed to meet their energy needs. During the experimental trials, participants completed two separate evening exercise sessions (50 min@70%Wmax + ~24 min time-trial (TT)) with either pre- or post-exercise CHO ingestion (253 ± 52 g), matching the CHO oxidized during exercise. The CHO drink and a volume-matched placebo (PLA) drink (containing no energy) were randomly assigned to be consumed two hours before and directly after the experimental exercise sessions. Post-exercise nocturnal interstitial glucose levels (24:00–06:00) were continuously monitored, and a 120-min OGTT was conducted the following morning to assess substrate oxidation rates and glucose control.
Results: Pre-exercise CHO intake significantly lowered capillary glucose levels during steady-state exercise (mean difference 0.41 ± 0.27 mmol/L, $p = 0.001$) without affecting perceived exertion and

ARTICLE HISTORY
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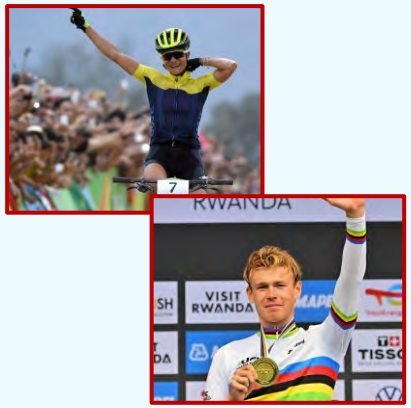
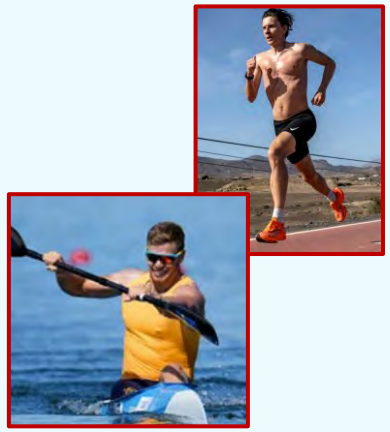
KEYWORDS
Carbohydrate metabolism; continuous glucose monitoring; exercise; fat metabolism; glucose tolerance test; nutrition

CONTACT Stig Mattsson stig.mattsson@oru.se Örebro University, Institute of Medical Sciences, Örebro, Sweden
Supplemental data for this article can be accessed online at https://doi.org/10.1080/15502783.2025.2494839

SVERIGES OLYMPISKA KOMMITTÉ

2006





KOMBINATIONEN ELITIDROTT & FORSKNING

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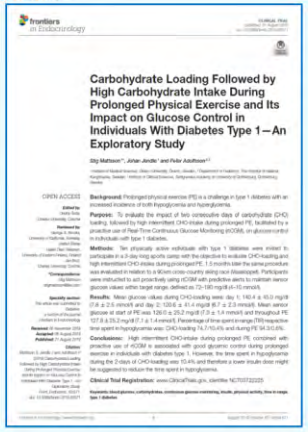

Carbohydrate Loading Followed by High Carbohydrate Intake During Prolonged Physical Exercise and Its Impact on Glucose Control in Individuals With Diabetes Type 1—An Exploratory Study

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STRATEGIER - LÅNGVARIG FYSISK AKTIVITET

Inför, under och efter fysisk aktivitet

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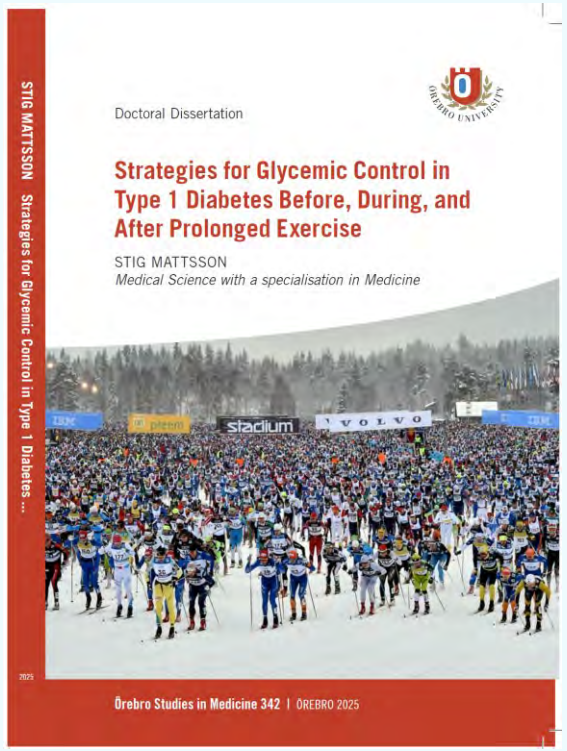
Avhandling 2025



Vasaloppet 2014

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Peter Adolfsson
peter.adolfsson@regionhalland.se
Stig Mattsson
stig.mattsson@ltdalarna.se
Johan Jendle
johan.jendle@liv.se

1 Institute of Clinical Sciences, The Sahlgrenska Academy at University of Gothenburg, Gothenburg, Sweden
2 Endocrine and Diabetes Center, The hospital of Halland Kungsbacka, Kungsbacka, Sweden
3 Faculty of Health Sciences and Medicine, Örebro University Hospital, Örebro, Sweden
4 Endocrine and Diabetes Center, Falun Hospital, Falun, Sweden
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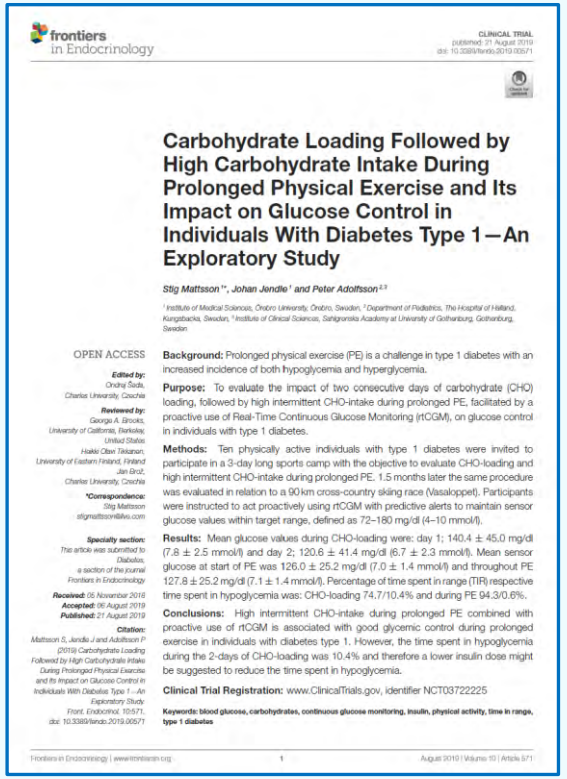

frontiers in Endocrinology

CLINICAL TRIAL
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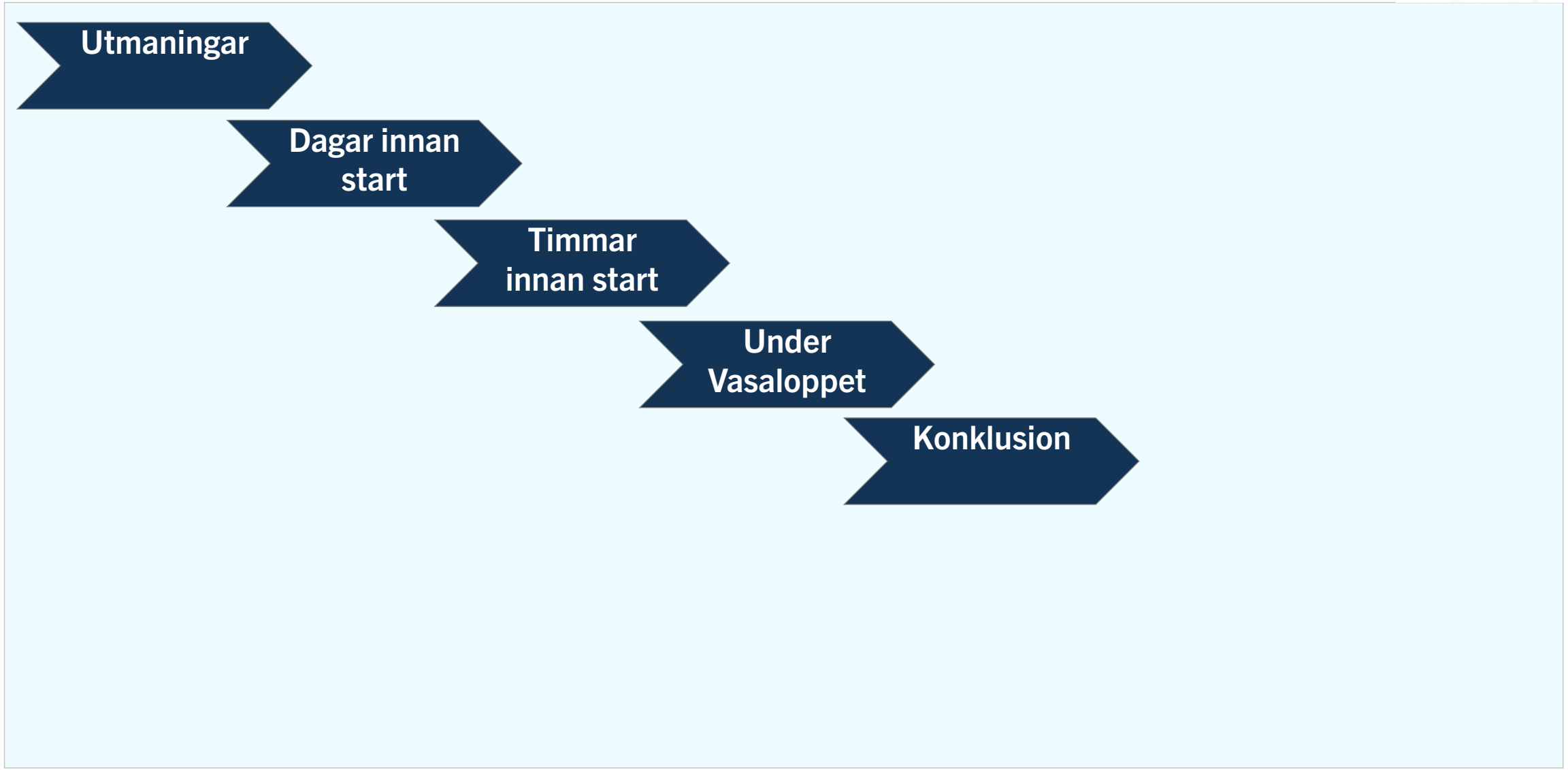


IDROTT OCH TYP 1 DIABETES

Foto: Stafettvasan

Att delta i olika typer av ”långlopp” har blivit allt mer populärt

Motion/tävling/utmaning….

Även personer med typ 1 diabetes vill delta….


Foto: Gaby Lopez, Pexels

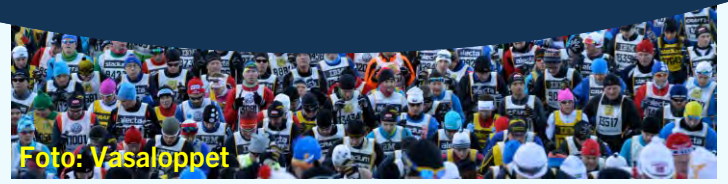
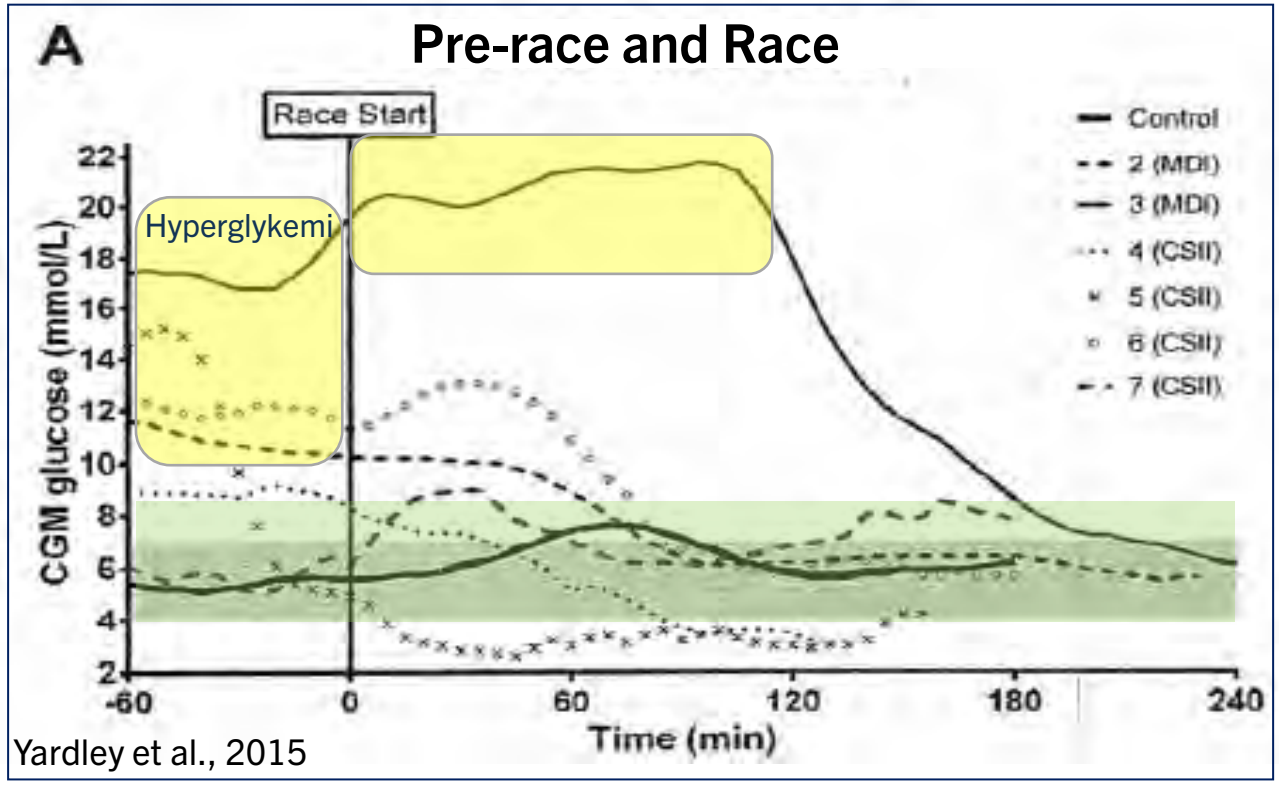


Foto: Vasaloppet


Foto: Pixabay

Observationsstudie – motionslopp cykel – 70 km

Personer med typ 1 diabetes



Yardley et al., 2015

Problem vid fysisk aktivitet

- Hyperglykemi vid start
- Hyperglykemi vid start → kan inte fylla på med kolhydrater (CHO)
- Lågt CHO-intag ökade risken för hypoglykemi i slutet av loppen
- Ökad risk för hypoglykemi efter fysisk aktivitet

Rekommendationen 2014 var att kraftigt minska basinsulinet (ca 50%) för att minska risken för hypoglykemi under långvarig fysisk aktivitet

Fysiologi – kunskap om hur kroppen fungerar

Faktorer som påverkar valet av strategi → insulin, kolhydrater etc.

INSULIN
INSULINKÄNSLIGHET
HORMONELL MOTREGLERING
GLUKOSREGLERING
FYSIOLOGI FYSISK AKTIVITET
…..

TRÄNINGSERFARENHET
TRÄNINGSPASSET (intensitet/duration)
GLYKOGENFÖRRÅD
ENERGI & KOLHYDRATBEHOV
KOLHYDRATRÄKNING
……

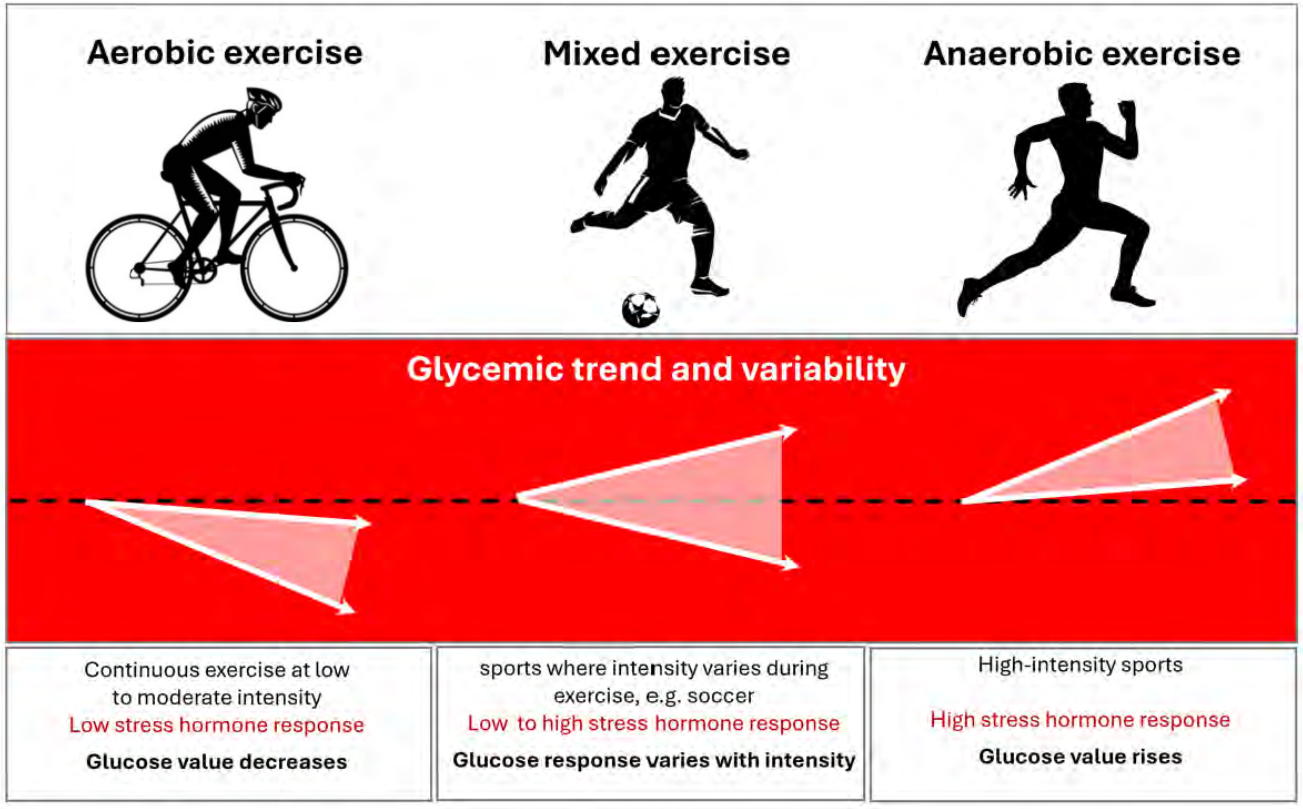
Citat: ”After the camps, I have a completely different sense of security in practicing sports.”

Slutsats:
Idrottsläger (teoretisk + praktisk utbildning) → ökar trygghet, självständighet och autonomi

Visar behov av riktad utbildning för både personer med T1D och vårdpersonal, i syfte att öka kompetensen kring T1D och fysisk aktivitet

Hur blodsockret påverkas av olika typer av idrott

Intensitet och hormonell reglering

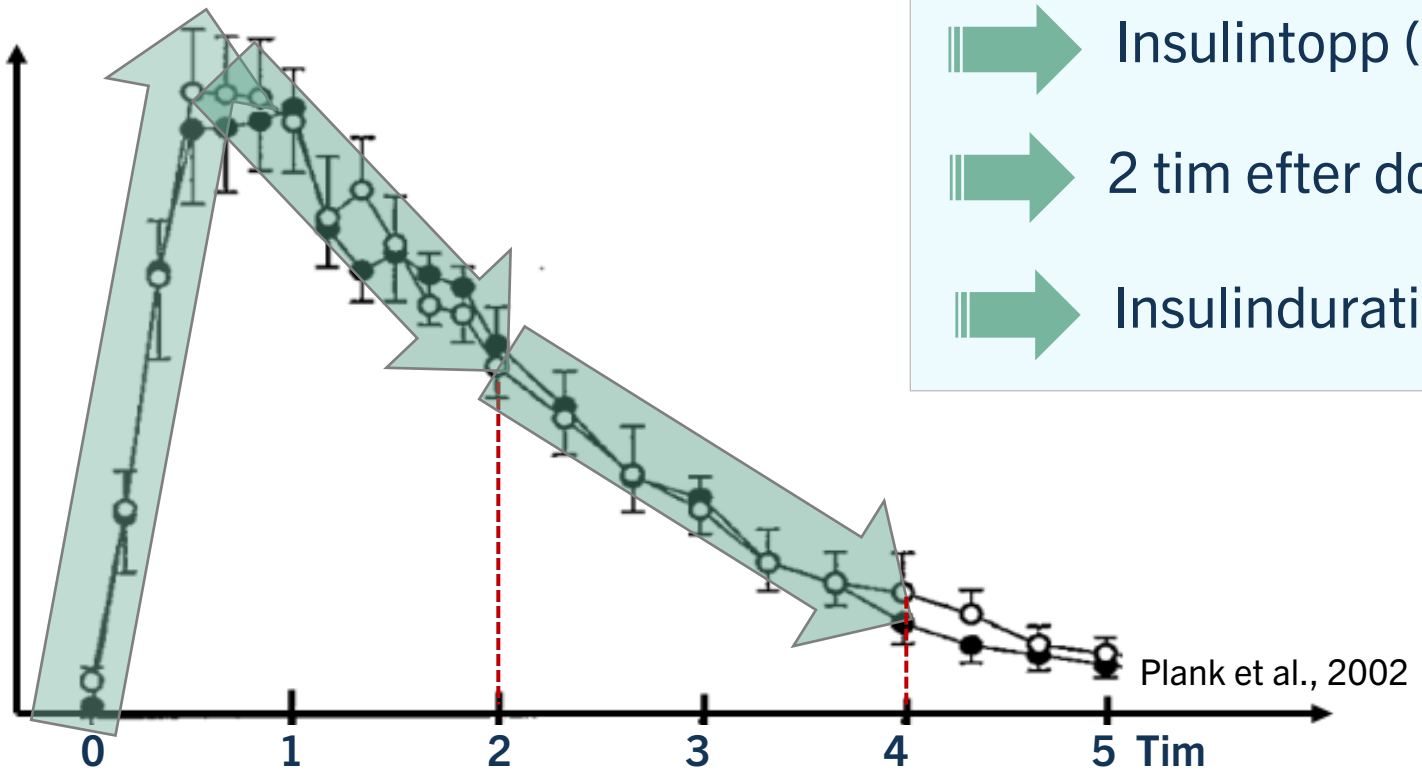


Lämpliga insulinjusteringar inför, under och efter fysisk aktivitet kräver kunskap om hur aktiviteten påverkar blodsockret

Insulinnivåer hos personer med typ 1 diabete

Förutbestämd insulinprofil

Insulinprofil
7E (0,1E/kg)
(Aspart (Novo Rapid)
& Lispro (Humalog))



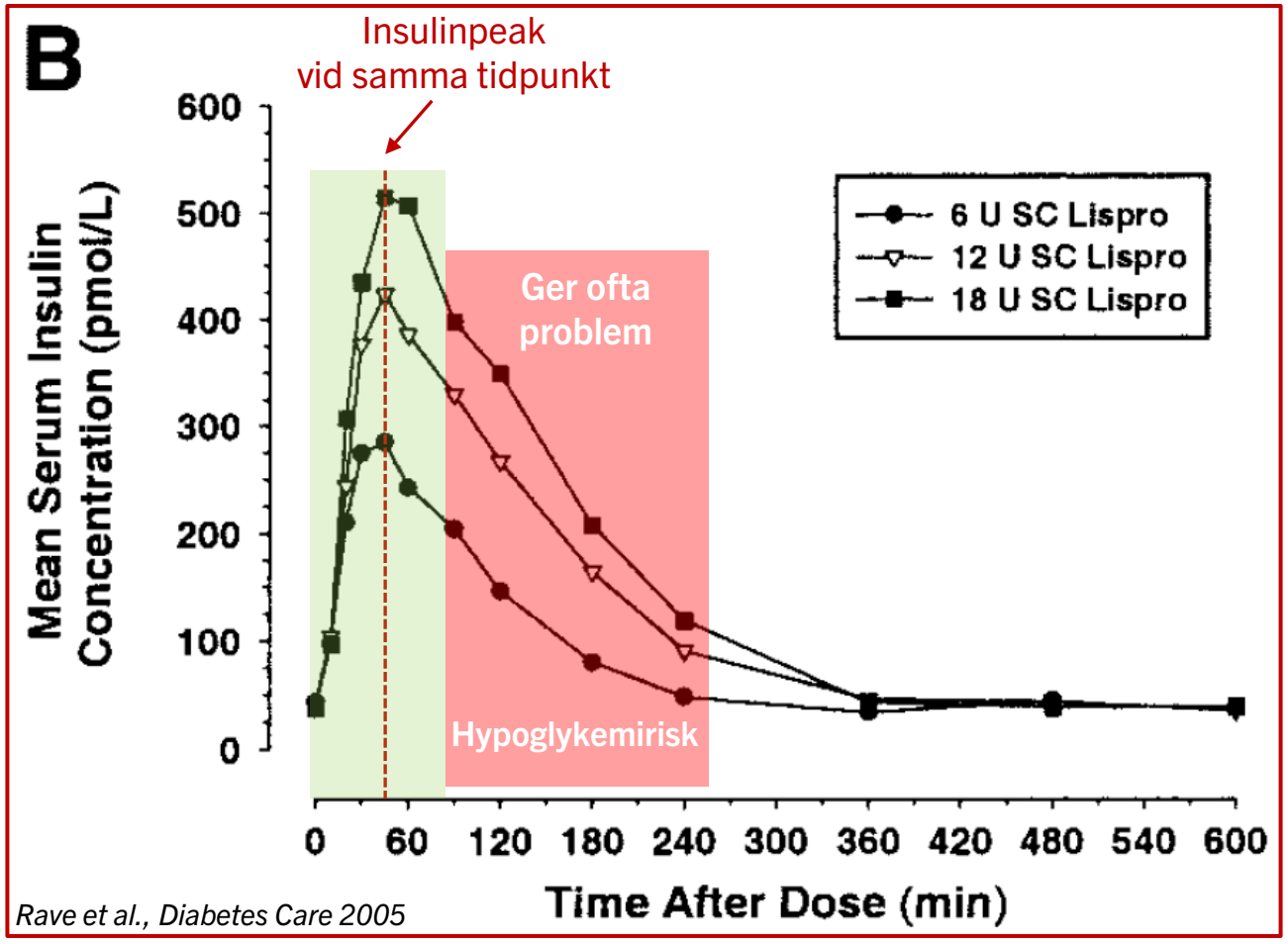
Plank et al., 2002

- Insulintopp (peak) ca 50 min efter dos
- 2 tim efter dos – ca 50% av max konc
- Insulinduration – ca 3-4 tim

En insulindos har en förutbestämd profil – lång tid till peak och för lång duraration.
Detta ställer krav hos personer med T1D att kunna planera sina insulindoser

Insulinprofil efter olika insulindoser

Lispro (Humalog) – 6, 12 & 18 E

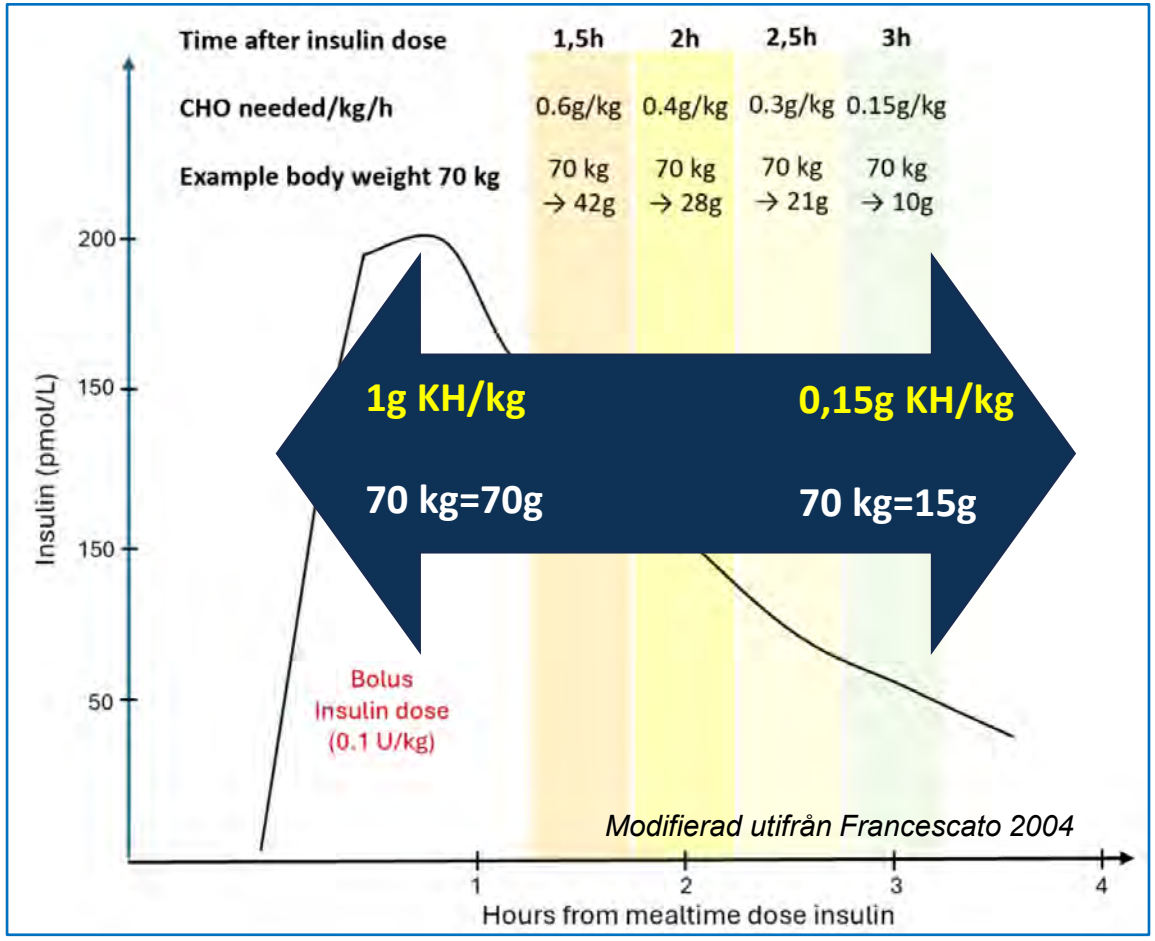


Rave et al., Diabetes Care 2005

- Insulintopp (peak) påverkas inte nämnvärt av dosens storlek
- Insulintopp (peak) ca 50 min efter dos
- Större insulindos ökar risken för sen hypoglykemi
- Träning nära inpå måltid
  → reducera måltidsdos med 25-75%

Att träna nära inpå en måltid

Att kunna bedöma mängden ”aktivt” insulin och behovet av kolhydrater



Träning nära inpå en måltid innebär nästan alltid att vi har för mycket insulin i kroppen

↓

HYPOGLYKEMI

↓

BEHOV AV KOLHYDRATER

Blodsockret kan både stiga och/eller sjunka väldigt snabbt inom idrott

Vid maximala insatser kan hyperglykemi nås inom 10-15 min

Vältränade har högre adrenalinrespons än otränade

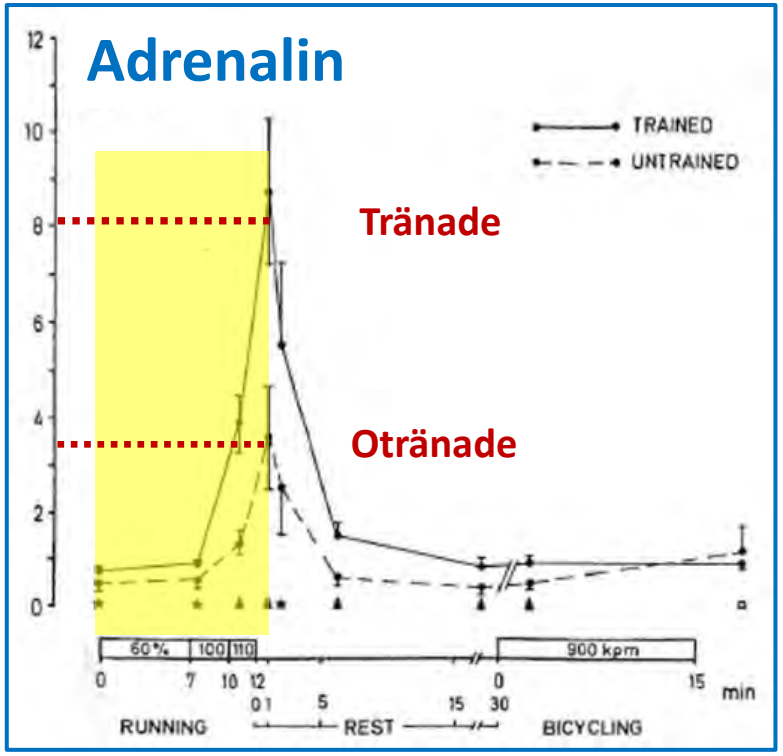
Högintensivt/explosivt arbete

1986

Increased epinephrine response and inaccurate glucoregulation in exercising athletes

M. KJÆR, P. A. FARRELL, N. J. CHRISTENSEN, AND H. GALBO

8 vältränade, 23 år
Löpare, längdåkare
8 kontroller, 23 år
7 min: 60% VO2max
3 min: 100% VO2max
2 min: 110% VO2max



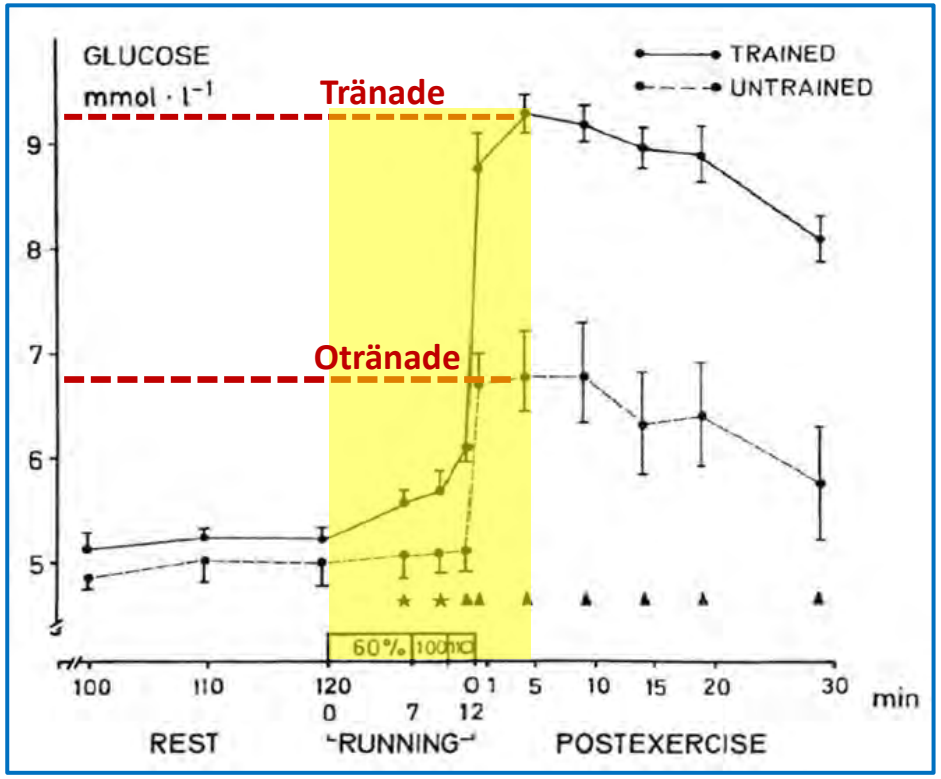
Kjaer et al., 1986

Vältränade hade en dubbelt så hög frisättning av adrenalin vid 110% VO2max i jämförelse med otränade individer (totalt 12 min arbete)

Vältränade har högre adrenalinrespons än otränade

Högintensivt/explosivt arbete

Glukos



Kjaer et al., 1986

Större ökning i blodsocker hos vältränade (65% högre) → Från 5,2 till 9,3 på 12 min i jämförelse med otränade personer.

Att öka insulinnivåerna inför ett högintensivt arbete

Adrenalin: Ökar leverns glukosfrisättning
Insulin: Minskar leverns glukosfrisättning

Följ ditt blodsocker via CGM

Ha alltid en kolhydratlösning med dig
→ Fyll på om ditt blodsocker sjunker innan start

Följ ditt blodsocker via kontinuerlig glukosmätning (CGM)
Vid behov → inta ”flytande kolhydrater” – saft, sportdryck etc.

VASALOPPET 2015

Foto: Stafettvasan

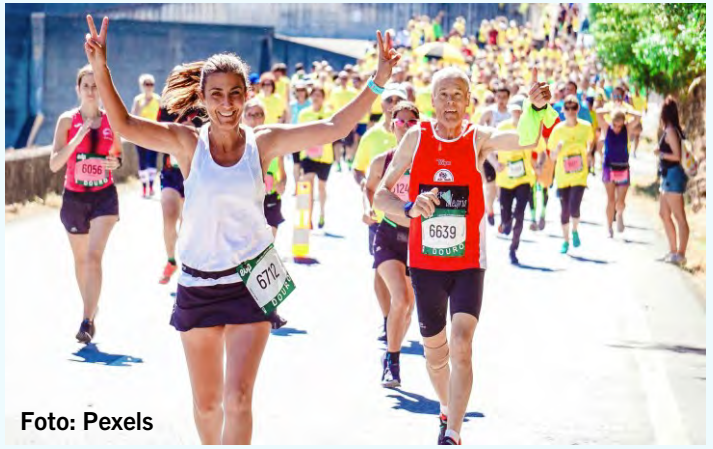


Foto: Pexels

Foto: Ultravasan

1. Kolhydratladdning 2. Starta med glukoskontroll 3. Stabilt blodsocker under Vasaloppet


Foto: Gaby Lopez, Pexels

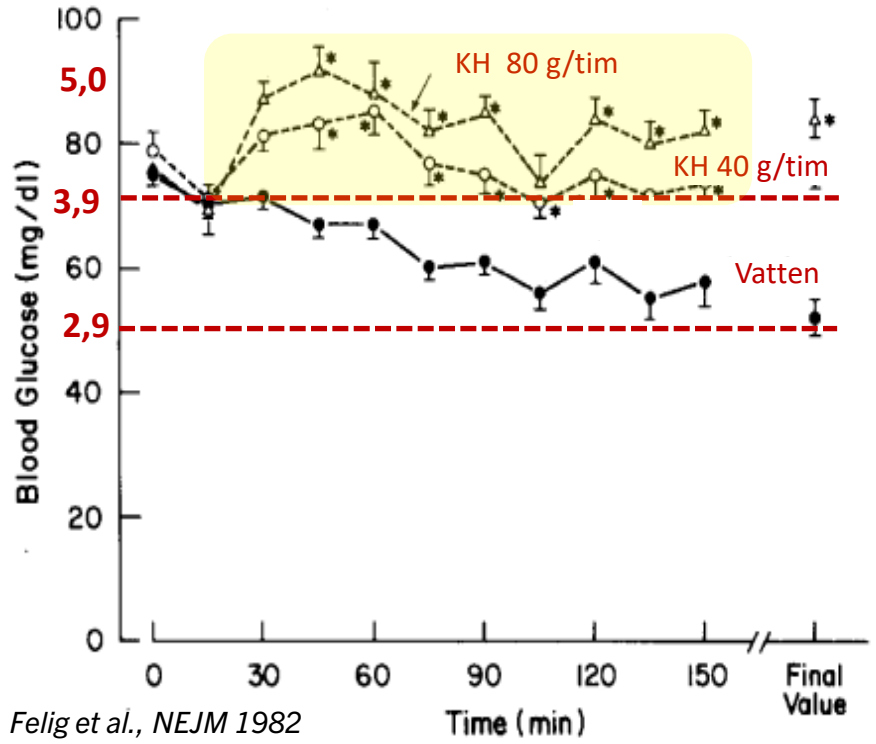

Foto: Vasaloppet


Foto: Pixabay

Glukos- och insulinnivåer vid långvarig fysisk aktivitet

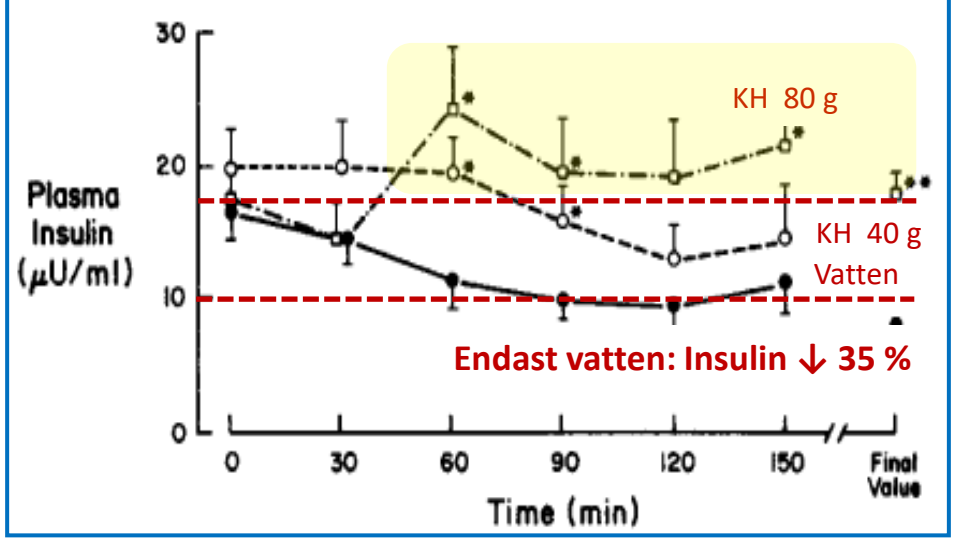
En studie från 1982 som gav idén till ”Vasaloppsstudien”

Blodsocker



Felig et al., NEJM 1982

Insulin



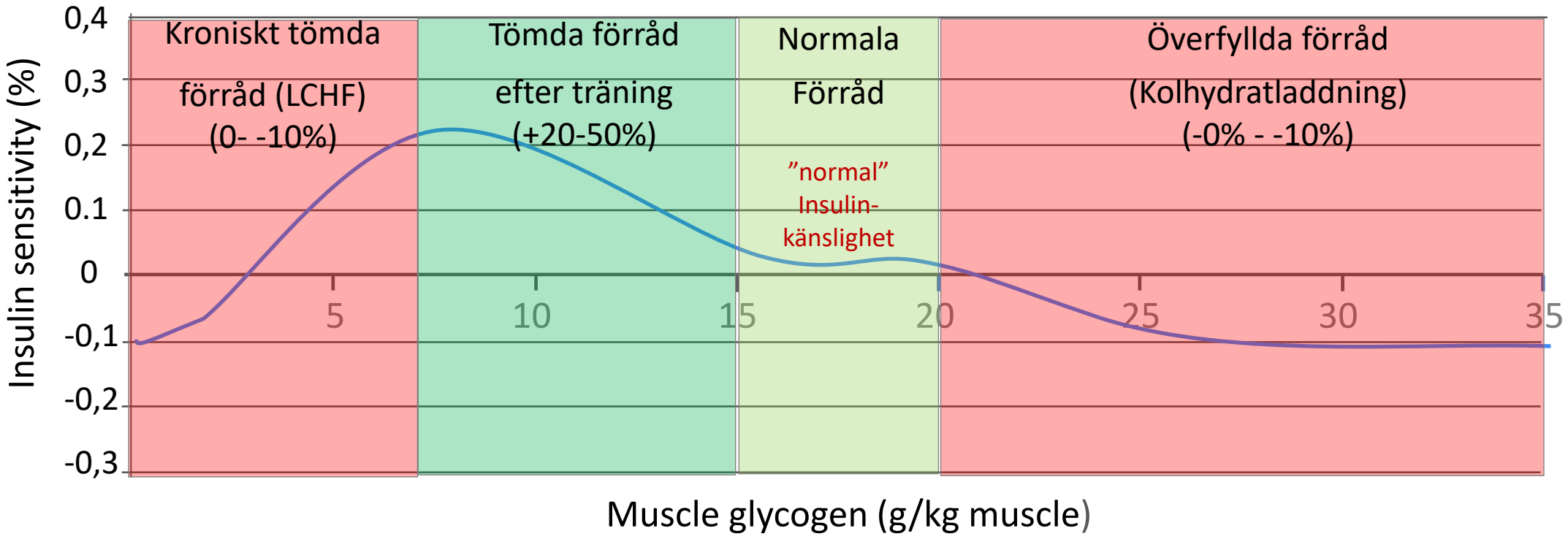
→19 st friska (18-47 år)
→ Normalvikt (kondition – medelmåttlig)
→ Stationär cykling
→ 60-65 % VO2max (”något ansträngande”)

Kolhydratintag 80 g/tim ⟶ Insulin något högre än innan fysisk aktivitet (vila)

Kolhydratladdning

Muskelglykogen och insulinkänslighet

Kolhydratladdning och insulinjustering



Glykogenförrådens storlek påverkar insulinkänsligheten

Hur ska vi justera insulinet under en kolhydratladdning?

Kolhydratladdning 2 dagar inför Vasaloppet

Den vanliga kosthållningen + 2g KH/kg kroppsvikt

Dag -2 och -1

2g KH/kg
Ex. 70 kg

70 kg x 2 =140g KH

+

Kolhydratkvot
Ex. 1E = 10g KH

140g/10 = 14E

- 15% = 12 E

KH-intag
12h (08.00-20.00)
→ 0,8 dl timme

Insulin: + 1 E/h

Natt -2 och -1

Natt 1

Basinsulin
+ 20%

Natt 2

Basinsulin
+ 30%

Dag 1 och 2

Måltidsinsulin

Vanlig insulindos

Korrektionsdos

Vanlig insulindos

KOLHYDRATLADDNING

Resultat Utvärdering av ett två-dagars kolhydratladdningsprotokoll med CGM

- **Medelglukos: 7,2** ± 2,4 mmol/L (dag 1: 7,8 ± 2,5 mmol/L, dag 2: 6,7 ± 2,3 mmol/L)
- **Time in Range** (4–10 mmol/L): **74,4%** (dag 1: 70,7%, dag 2: 78,3%)
- **Tid i hypoglykemi** (<4 mmol/L): **10,4%** (dag 1: 9,9%, dag 2: 10,8%)

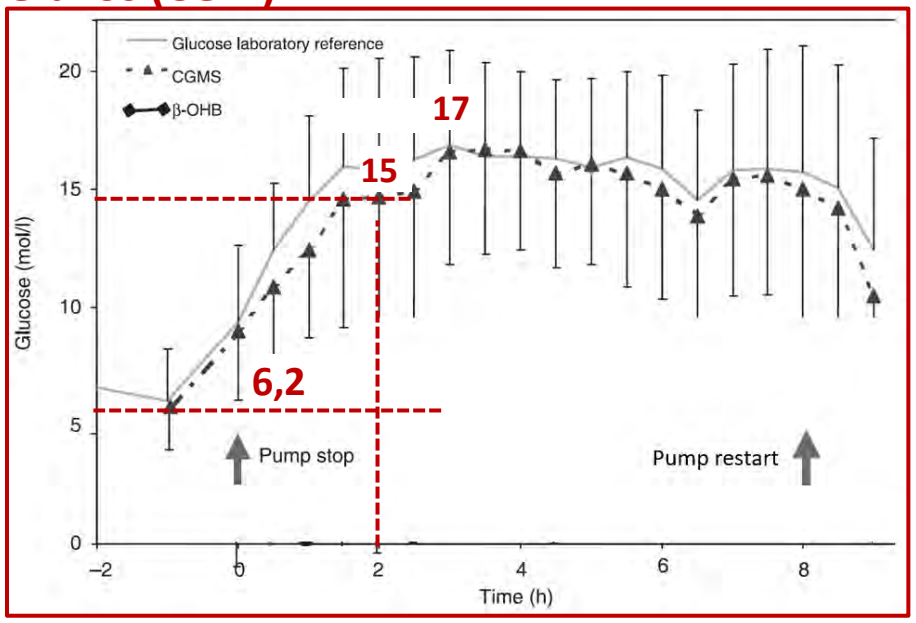
Slutsats: Två dagars kolhydratladdning med ökade nivåer av basinsulin gav en bibehållen glukoskontroll. Något lägre nivåer av basinsulin bör dock rekommenderas eftersom 10,4% av tiden tillbringades i hypoglykemi

Att starta med ett ”bra blodsocker”
(5-8 mmol/l)

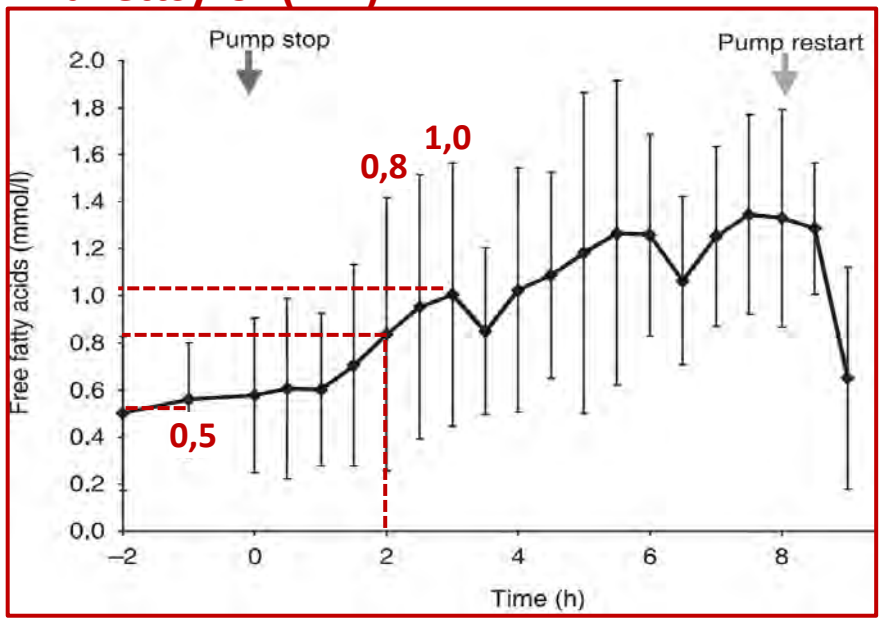
Att stoppa insulinpumpen 8 timmar

Förändringar i glukos och fria fettsyror

Glukos (CGM)



Fria fettsyror (FFA)



2 tim löpning
endast intag av vatten

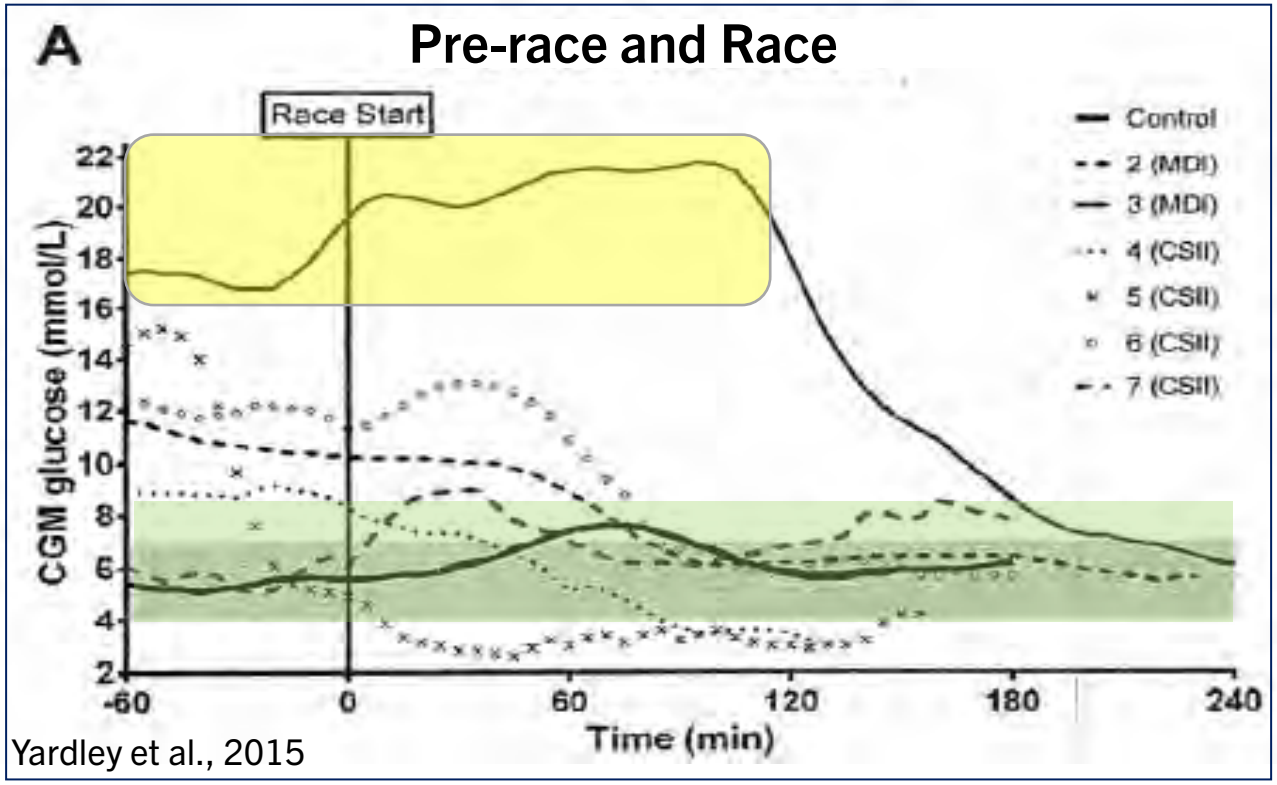
→ FFA ca 1 mmol/l

Pfützner et al., Diabetes Med, 2006
Boden et al., J Clin Invest, 1994

En förhöjning av FFA till 0,8 mmol/l hos personer utan diabetes
Halverade det muskulära glukosupptaget (-50 %) i vila

Observationsstudie – motionslopp cykel – 70 km

Personer med typ 1 diabetes



Yardley et al., 2015

En ökning av fria fettsyror (FFA)

→ Muskeln minskar glukosupptaget från blod

→ Ett minskat muskulärt glukosupptag påverkar prestationsförmågan negativt

Nervositet (adrenalin) inför en tävlingsstart kan medföra att blodsockret stiger

Högt blodsocker en längre tid (ca 1-2 tim) medför även en ökning av mängden fria fettsyror (FFA)

Utmaningar | Dagar innan start | **Timmar innan start** | Under Vasaloppet | Summering

Att starta med ett blodsocker mellan 5-10 mmol/l

Att motverka nervositetens blodsockerhöjande effekt

Insulindos till frukost ska ta hand om:

→ Måltid

→ Stresspåslag före start (nervositet)

Före tävlingsstart

→ Vid behov → kolhydratlösning (30-40g)

→ CGM

Frukostdos ökades med 55,5%

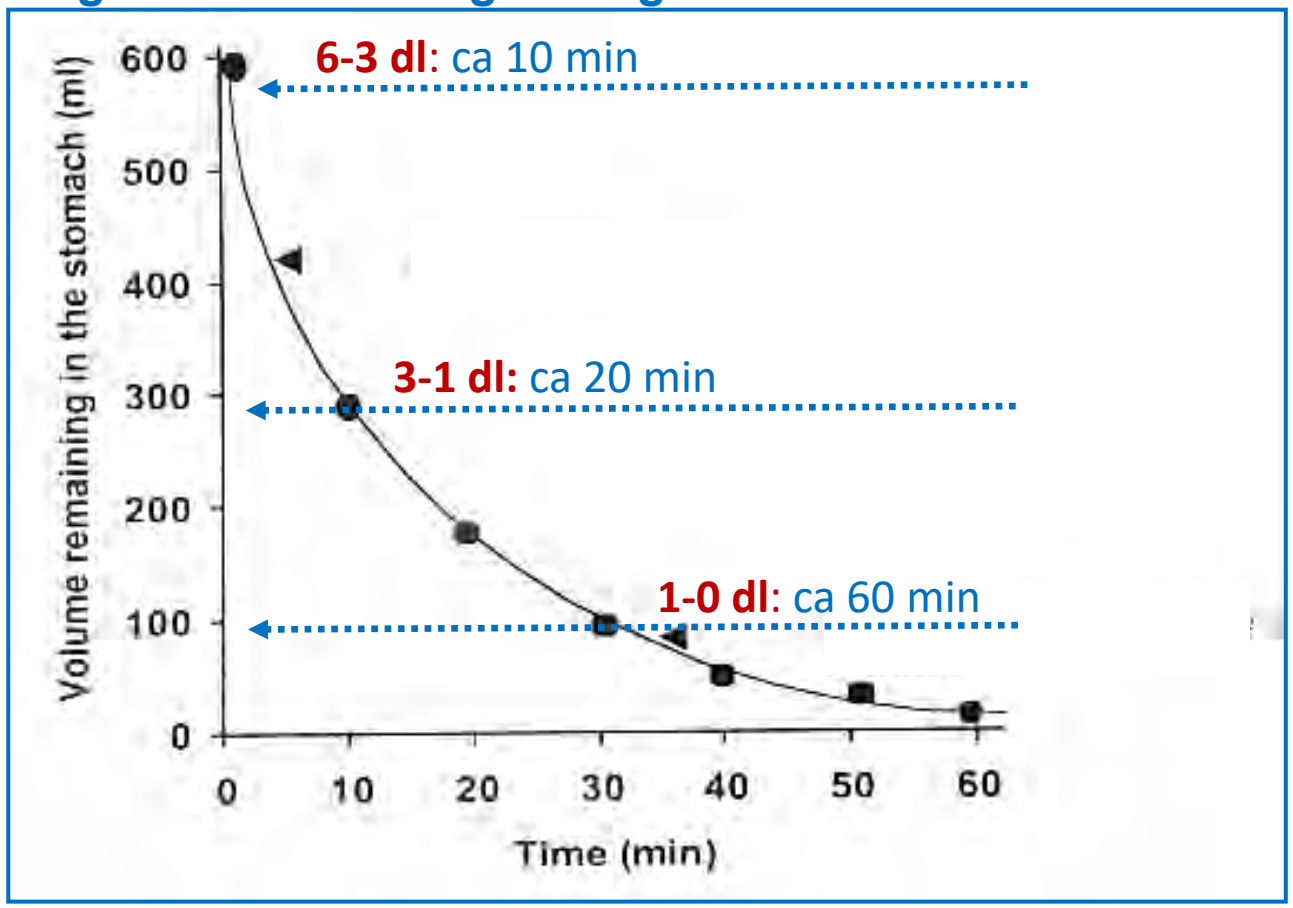
Medel 5,4±3E → 8,4±4E

Medelglukos vid start 7±1,4 mmol/l

Att höja blodsockret snabbt

Magsäckstömning

Magsäckens tömningshastighet



Ronald J. Maughan and Robert Murray. *Sports Drinks*, 2000.

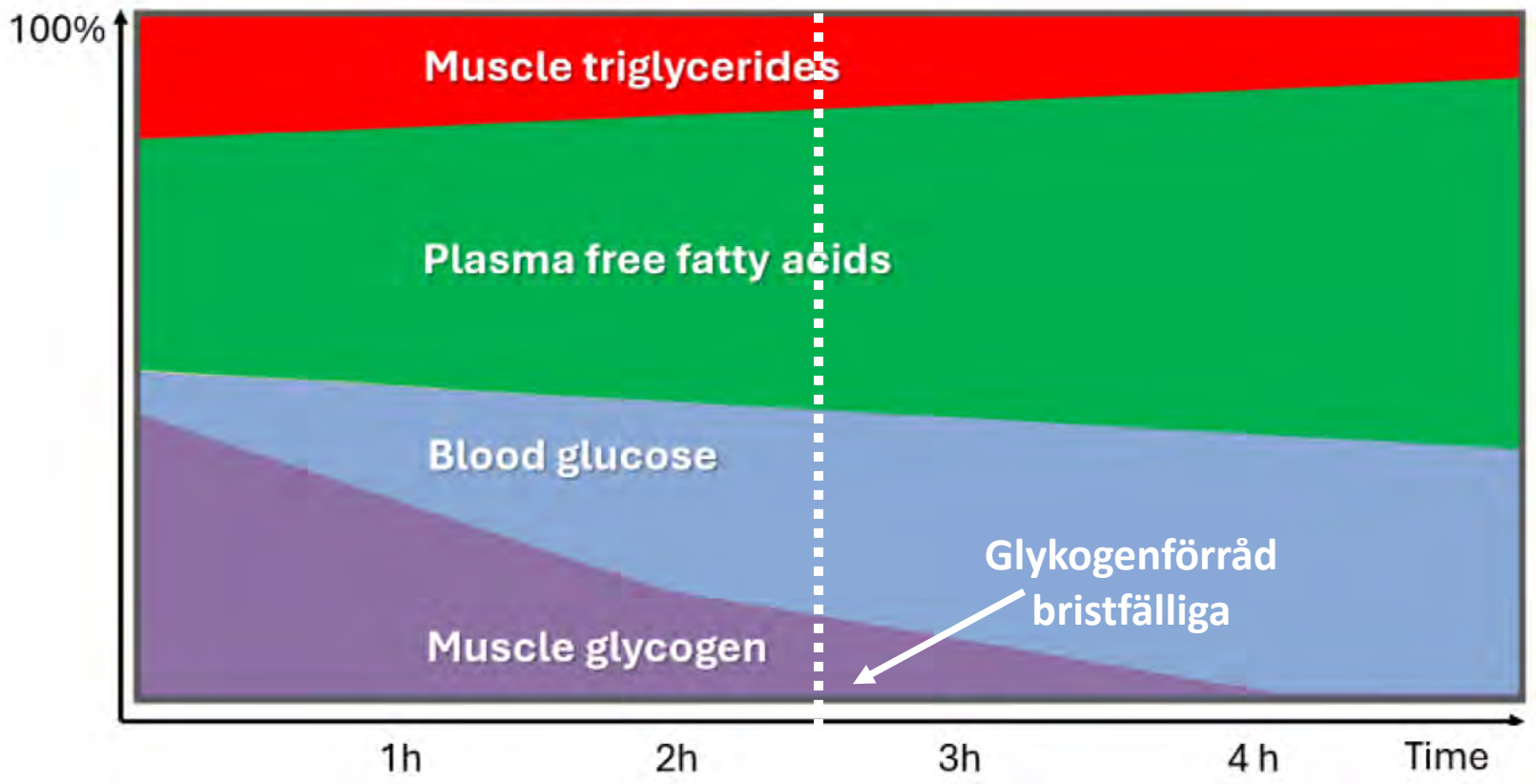
För snabb magsäckstömning vid träning
→ Ta ”flytande” kolhydrater
→ Dextrol utan vätska tar längre tid

Magsäckstömningen är väldigt snabb när du har lite en högre volym i magsäcken

Stabil glukoskontroll under Vasaloppet
(4-10 mmol/l)

Bränslekällor under långvarig fysisk aktivitet

Glykogenförråden i lever och muskler är relativt små



-Vid lågt KH-intag ökar FFA vilket minskar musklernas glukosupptag.

-En ökning av FFA påverkar även glukoskontroll

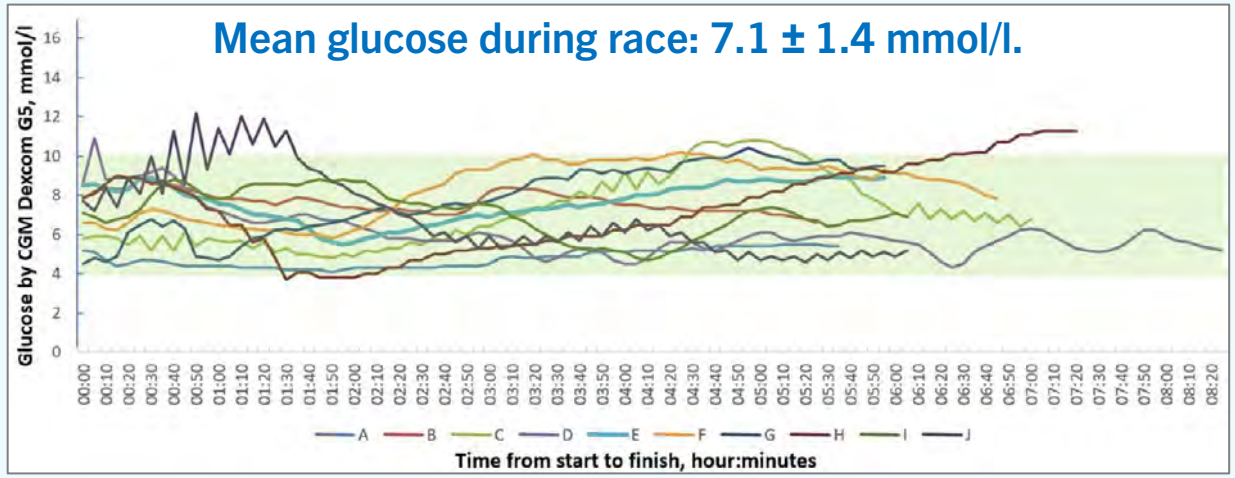
Blodsocker viktig källa till KH i slutet av långvarig fysisk aktivitet

För att uppnå ett stabilt blodsocker och en hög prestationsförmåga under långvarig fysisk aktivitet måste vi främja en hög kolhydrattillgänglighet

Vasloppet 2015

Resultat Utvärdering av glukoskontroll under Vasaloppet 90 km (75g KH/tim)

Glukoskontroll under Vasaloppet 90 km



- Glukos låg inom målområdet (4–10 mmol/L) 94,3% av tiden, med endast 0,6% i hypoglykemi
- Ingen deltagare sänkte basinsulinet under Vasaloppet; en deltagare ökade det med 28%

Slutsats: Ett högt kolhydratintag (75-100 g/tim) i kombination med balanserade insulindoser och proaktiv användning av CGM var säkert och möjliggjorde en utmärkt glukoskontroll under långvarig fysisk aktivitet

Konklusion

Vad har vi lärt oss?

INSULIN

HORMONELL MOTREGLERING

INSULINKÄNSLIGHET

GLUKOSREGLERING

TRÄNINGSERFARENHET

TRÄNINGSPASSET

GLYKOGENFÖRRÅD

KOST/KOLHYDRATER

Vi kan idag skapa strategier för stabil glukoskontroll vid fysisk aktivitet
– men det kräver kunskap inom fysiologi och individanpassning.

→ Dock har de insulin vi har idag har för långsam tid till peak och för lång duration

Tackar så mycket för er uppmärksamhet!