Glucose-lowering effects of physical activity in type 1 diabetes: A causal modelling and matched-pair analysis approach

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Disclosures

I am supported in preparing content by ***Chad***, my ChatGPT AI Assistant. All ideas, interpretations, and responsibility remain my own. Chad helps polish and refine language to make content more engaging and accessible.

Honoraria / Speaking Fees

- ROCHE Diabetes
- Dexcom
- Insulet
- Abbott
- SBK Healthcare
- EXTOD
- Ypsomed

Consulting / Advisory Roles

- ROCHE Diabetes
- Abbott

Non-Profit Work

- Owner and Creator of ***www.TheGlucoseNeverLies.com***

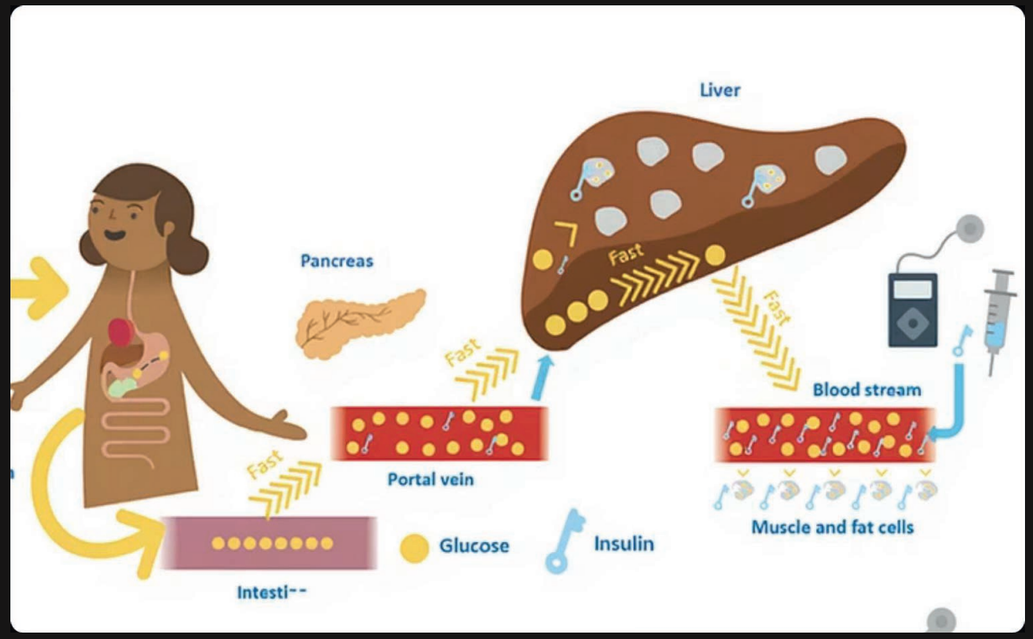
Barriers to Physical Activity in T1D

less than 50% of individuals with type 1 diabetes meet recommendations

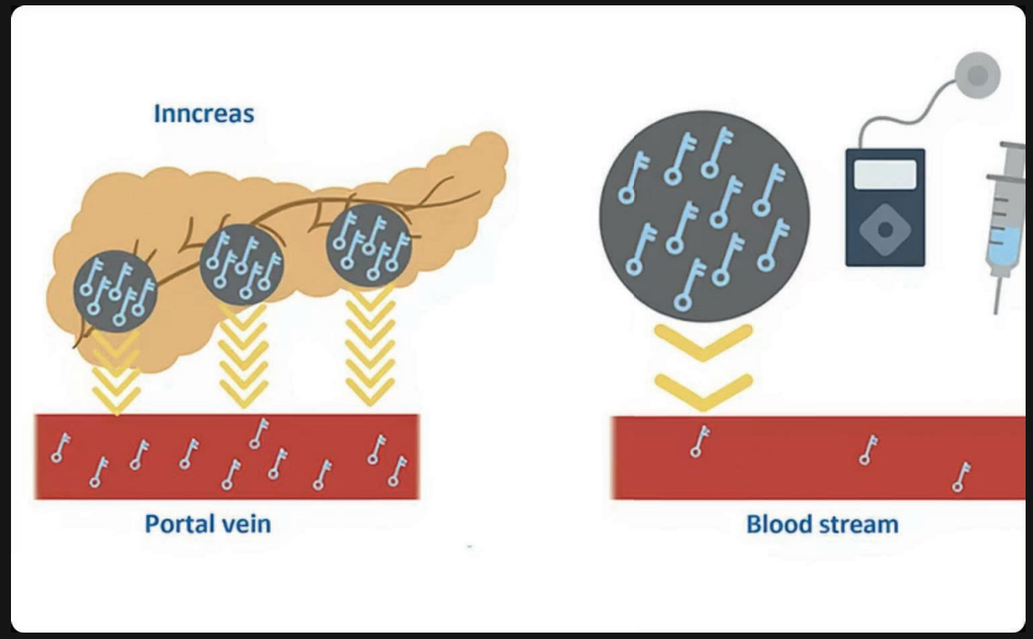
- **Fear of Hypoglycaemia**
- **Complex Management Requirements**
- **Lack of Education**
- **Social and Psychological Factors**

References: Appl Physiol Nutr Metab. 2021;46:95-107. Canadian journal of diabetes. 2024;48:105-11.e5. PLoS One. 2014;9:e108019. Canadian journal of diabetes. 2024;48:401-8. Diabetic medicine: 2024;41:e15149. *BMC Public Health 22, 1964 (2022).* https://doi.org/10.1186/s12889-022-14385-1

Type 1 Diabetes Insulin Challenges



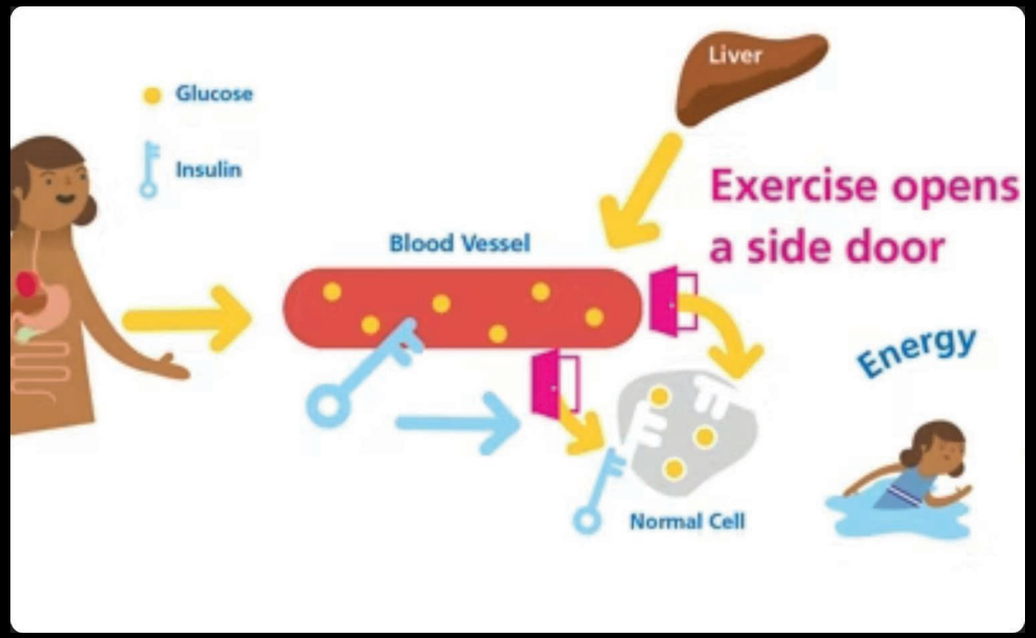
Low portal vein insulin concentrations



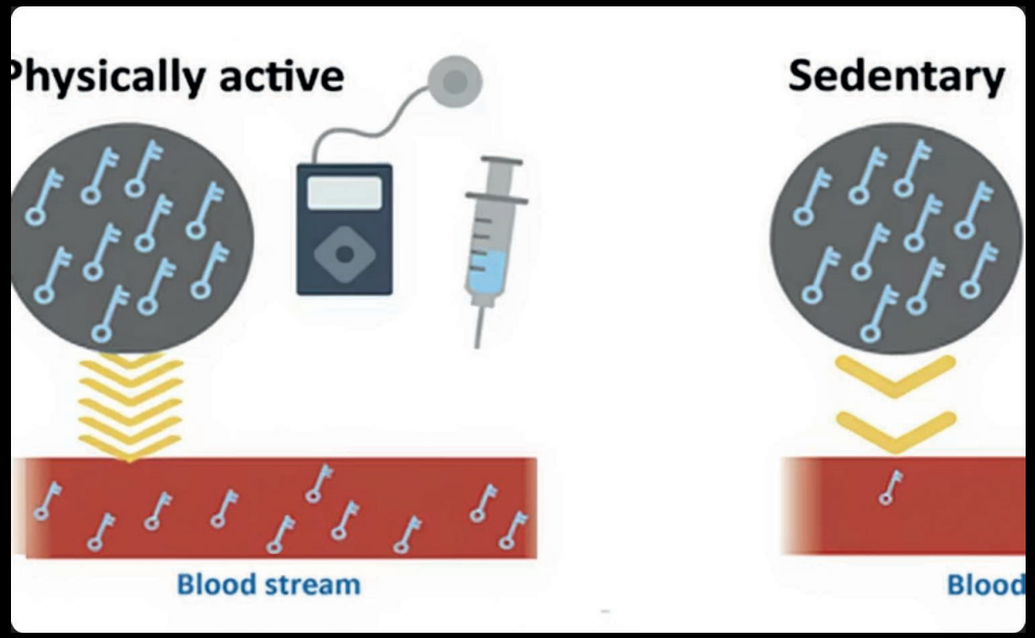
Slow subcutaneous insulin absorption

References: Diabetic Med. 1998; (15): 972-978; Diabet Med. 2018;35(3):306–16; J Diabetes Sci Technol. 2017;11:753-8.; Diabetes Res Clin Pract. 2013;99:19-23

Physical Activity to the Rescue



Non-insulin Mediated Uptake



Faster Insulin Absorption

Diabetes Obesity & Metabolism (2024). https://doi.org/10.1111/dom.16088; Nat Rev Endocrinol. 2017 Mar 1;13(3):133–48.; Physiol Rev. 2015;95(2):549–601.

Duration of physical activity required to Ameliorate hyperglycemia without causing hypoglycemia in type 1 diabetes: A T1DEXI adults and pediatric cohort analyses

John Pemberton [a] · Zoey Li [b] · Robin L. Gal [b] · Lauren V. Turner [c] · Simon Bergford [b] · Peter Calhoun [b] · Michael C. Riddell [c] Show less

Affiliations & Notes Article Info

a Birmingham Women's and Children's Foundation Trust, Birmingham, United Kingdom

"But John... There's No Control!"

Peter Calhoun: "It's nice data, but John, there is no control. The glucose may have dropped without activity!"

John Pemberton: "I know a Data Scientist I can challenge to take on a matched pair analysis"

Catherine Russon: "Challenge accepted!"

Clin Pract. 2025 Feb;220:111981. doi: 10.1016/j.diabres.2024.111981

Study Overview: Aims, Criteria & Population

AIMS

Assess glucose changes during physical activity in adults and adolescents with T1D using a pair-matching approach

INCLUSION CRITERIA

Starting glucose >10.0 mmol/L (180 mg/dL)

Self-reported activity: 10-30 min

CGM data available ≥70% for 1 hour before and 20 mins after

STUDY POPULATION

T1DEXI: 561 adults

T1DEXIP: 225 adolescents

Study Overview

1

Data Acquired

T1DEXI: 561 adults (>10,000 bouts)

T1DEXIP: 225 adolescents (3,500+ bouts)

Total: 786 participants, >13,500 bouts

2

Eligibility Applied

- CGM ≥70%
- Insulin data
- ≥1 PA bout (10–30 min, start glucose >10 mmol/L)

Result: 1,944 candidate bouts

3

Exclusion

Removed duplicate bouts and those lacking sufficient pre/post data points.

Result: 1,546 activity bouts for matching.

4

Matched Pair Selection

Each activity bout matched with non-activity control periods.

Result: Control bouts identified for all 1,546 data points

5

Data Analysis

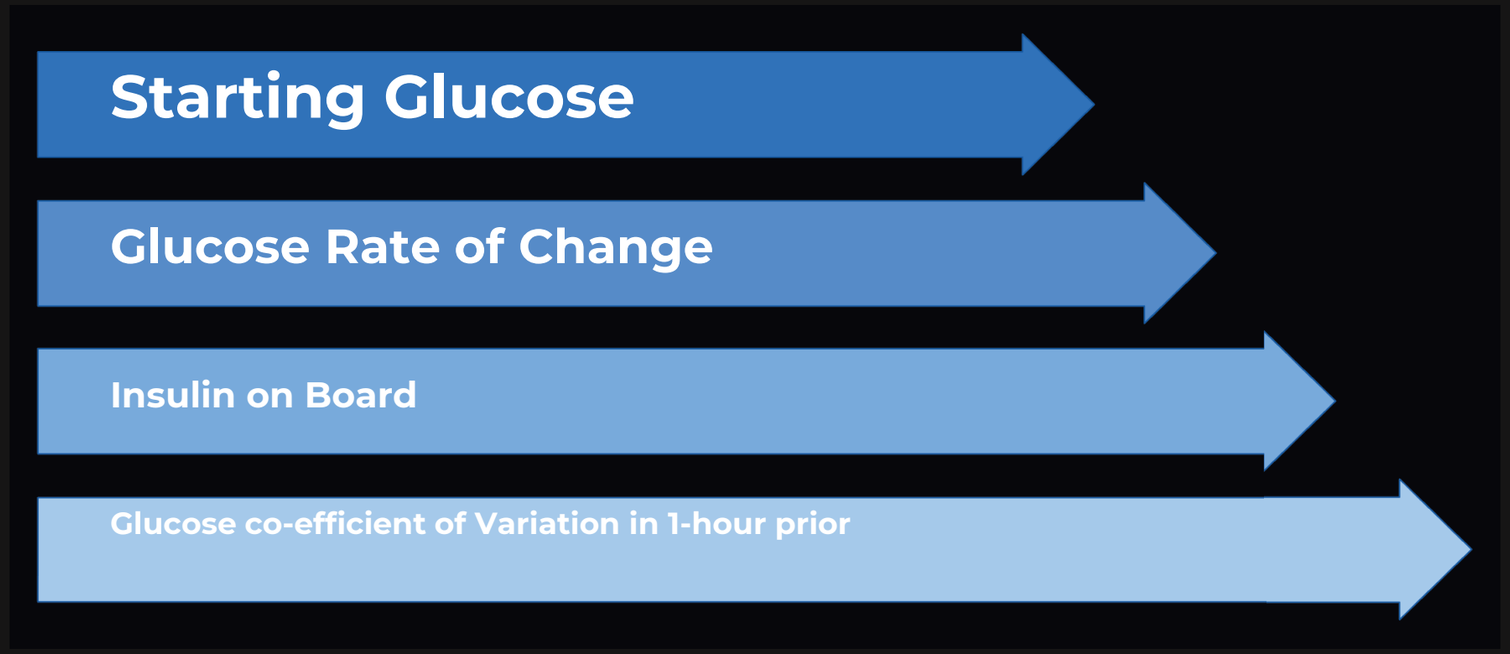
Causal modeling and mixed linear model applied.

Assessed glucose change during activity vs. control periods.

Identified individual and event-level moderators.

Hierarchal Variable Selection (Mixed Liner Model)

Within Participant Matching: Activity Day vs Matched No Activity Day



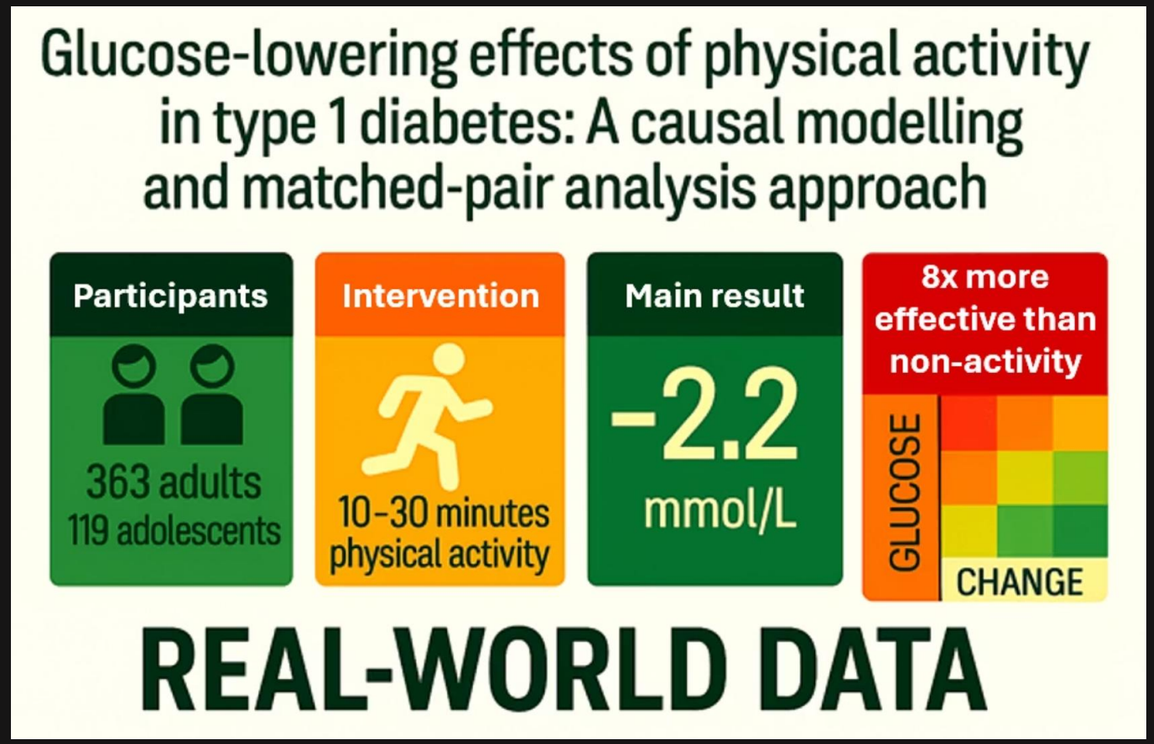
tinder

Acceptable
Threshold
SMD <0.1

eharmony

Our Matched-Pair
Analysis
SMD <0.01

Main Results



PA [median 23 minutes: IQR (20, 30)]

Mean glucose change of -2.2 mmol/L ($p<0.001$)

Matched Non-PA Periods

Mean glucose change of 0.3 mmol/L ($p<0.001$)

Mean Difference

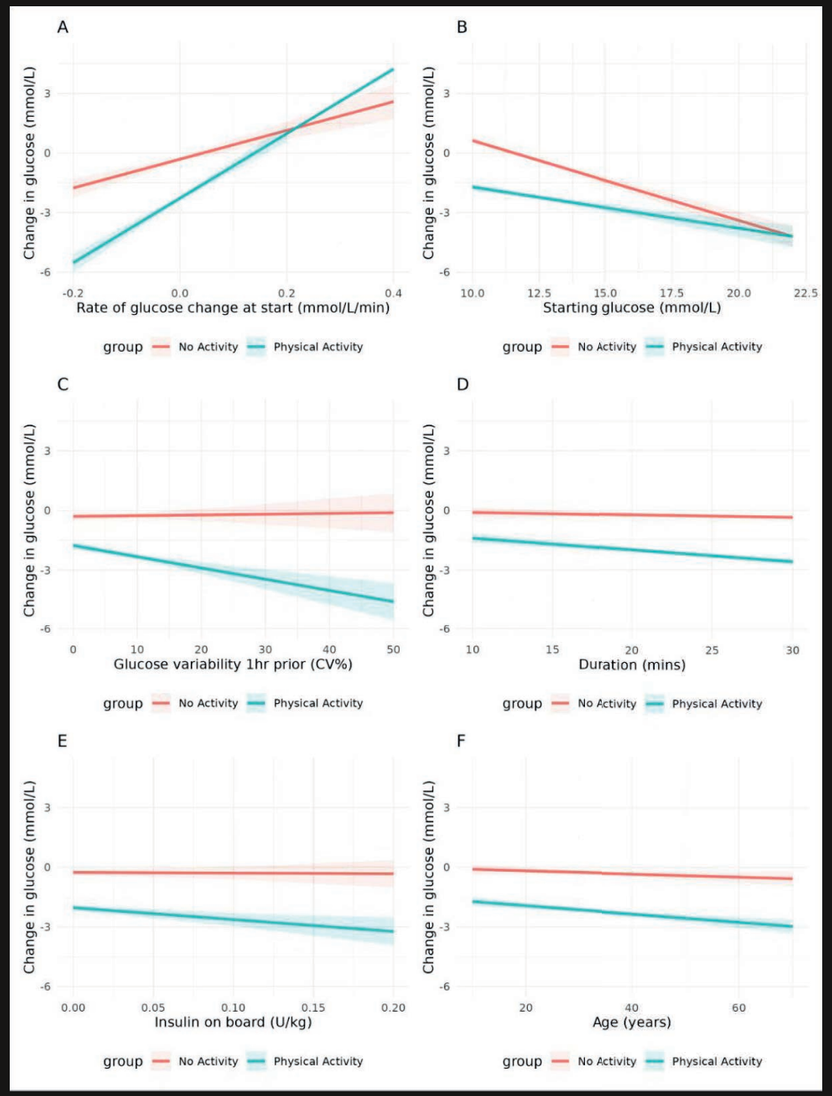
-1.9 mmol/L ($p<0.0001$)

No Significant Differences

By age, gender, activity type, intensity

Hypoglycaemia

Less than 2%



Individual- and Event-Level Moderators of the Differential Glucose Drop Between Physical Activity and Non-PA

Legend: This figure displays individual- and event-level factors that influenced the difference in glucose change between physical activity (PA) and matched non-PA periods:

(A) starting glucose rate of change

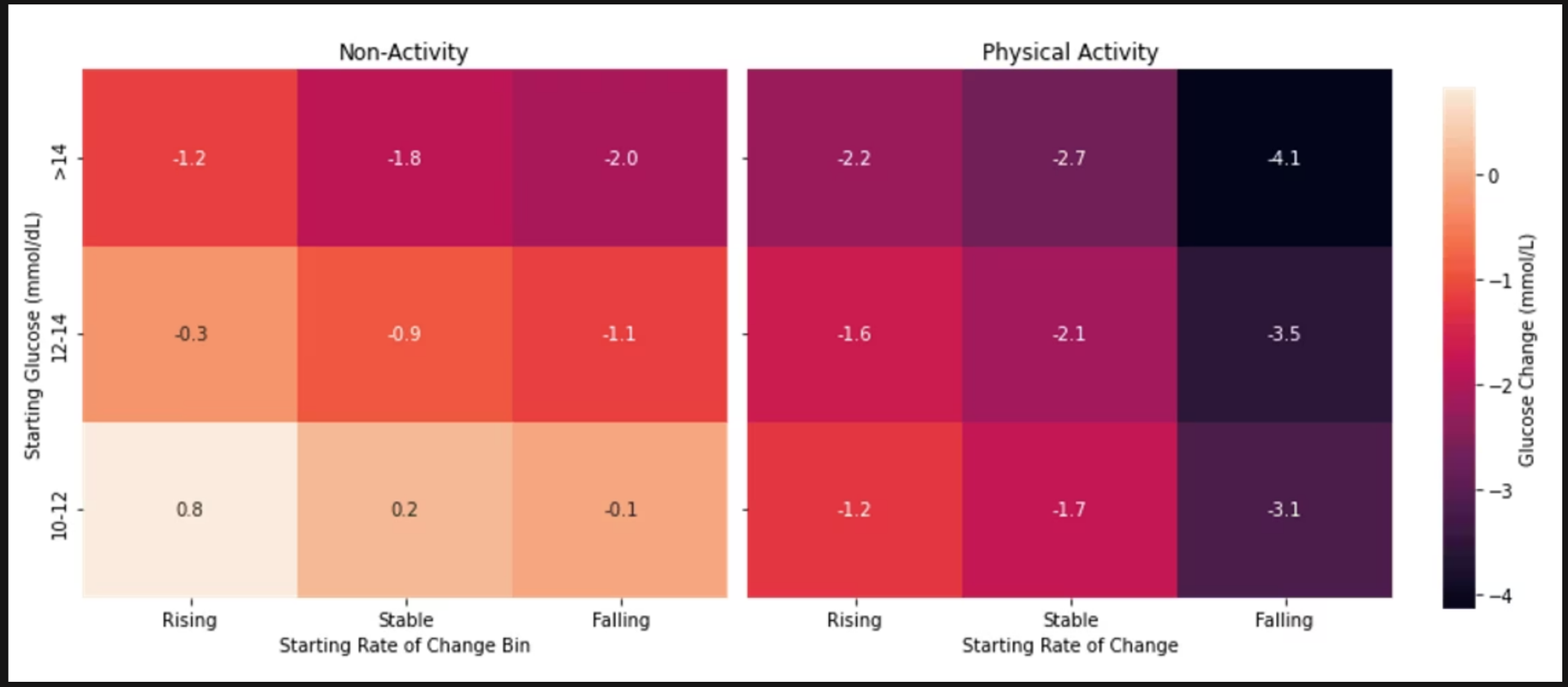
(B) starting glucose level

(C) Pre-PA (1-hour) glucose coefficient of variation (CV) (D) Activity duration

(E) starting insulin on board (IOB)

(F) Age

Predicted Glucose Trajectories Based on Physical Activity Status, Starting Glucose, and Glucose Rate of Change (mmol/L)



Predicted Glucose Trajectories Based on Physical Activity Status, Starting Glucose, and Glucose Rate of Change (mg/dL)

Strengths and Limitations

Strengths

High Ecological Validity

large sample size across wide age range

Rigorous Pair-Matching

Approach controlling for multiple predictors of glucose change

Consistency Across Cohorts

Findings replicated across all ages

Data Capture

CGM and pump Uploads

Limitations

Unable to Differentiate

Intensities of anerobic were low (heart rate)

Activity Bouts

Were of limited duration 10-30 mins

Short Observation Period

20-min post activity

Study Population Bias

Mainly white ethnicity and private health insurance

20 by 2

Physical Activity Rule

Hyperglycaemia in Type 1 Diabetes

Glucose level of more than 10 mmol/L

1. Bolus insulin within 4 hours[1]
2. Blood ketones <0.6 mmol/L (insulin pump), or <1.5 mmol/L (insulin injections)[2]

20 minutes of physical activity

Drop ~2 mmol/L[3]

Education

- Avoid this approach before breakfast
- At the discretion of the person living with diabetes

Safety Profile

- <2% risk of hypoglycaemia
- Very low chance of glucose rising
- Any type of physical activity

1. Pemberton JS, Li Z,et al. physical activity required to ameliorate hyperglycemia **Diabetes Res Clin Pract**. 2025 Feb 1;220.
2. Moser O, Zaharieva DP et al. ***EASD/ISPAD position statement.*** **Diabetologia.** 2024;1–26.
3. Pemberton JS, Russon CL, et al. *Causal matched-pair analysis.* **Diabet Med.** [In press]

20 by 40

Physical Activity Rule

Hyperglycaemia in Type 1 Diabetes

Glucose level of more than 180 mg/dL

1. Bolus insulin within 4 hours[1]
2. Blood ketones <0.6 mmol/L (insulin pump), or <1.5 mmol/L (insulin injections)[2]

20 minutes of physical activity

Drop ~40 gm/dL[3]

Education

- Avoid this approach before breakfast
- At the discretion of the person living with diabetes

Safety Profile

- <2% risk of hypoglycaemia
- Very low chance of glucose rising
- Any type of physical activity

1. Pemberton JS, Li Z,et al. physical activity required to ameliorate hyperglycemia **Diabetes Res Clin Pract**. 2025 Feb 1;220.
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- Michael C. Riddell

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- Brad Metcalf
- Emma Cockcroft
- Michael Allen
- Anne-Marie Frohock
- Rob Andrews

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“99 Problems But High Glucose Ain’t One”