nature portfolio

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Reporting Summary

Nature Portfolio wishes to improve the reproducibility of the work that we publish. This form provides structure for consistency and transparency in reporting. For further information on Nature Portfolio policies, see our Editorial Policies and the Editorial Policy Checklist.

Statistics

For all statistical analyses, confirm that the following items are present in the figure legend, table legend, main text, or Methods section.

n/a	Confirmed	
☐	☒	The exact sample size (*n*) for each experimental group/condition, given as a discrete number and unit of measurement
☐	☒	A statement on whether measurements were taken from distinct samples or whether the same sample was measured repeatedly
☐	☒	The statistical test(s) used AND whether they are one- or two-sided *Only common tests should be described solely by name; describe more complex techniques in the Methods section.*
☐	☒	A description of all covariates tested
☐	☒	A description of any assumptions or corrections, such as tests of normality and adjustment for multiple comparisons
☐	☒	A full description of the statistical parameters including central tendency (e.g. means) or other basic estimates (e.g. regression coefficient) AND variation (e.g. standard deviation) or associated estimates of uncertainty (e.g. confidence intervals)
☐	☒	For null hypothesis testing, the test statistic (e.g. *F*, *t*, *r*) with confidence intervals, effect sizes, degrees of freedom and *P* value noted *Give P values as exact values whenever suitable.*
☒	☐	For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings
☒	☐	For hierarchical and complex designs, identification of the appropriate level for tests and full reporting of outcomes
☒	☐	Estimates of effect sizes (e.g. Cohen's *d*, Pearson's *r*), indicating how they were calculated

Our web collection on statistics for biologists contains articles on many of the points above.

Software and code

Policy information about availability of computer code

Data collection	Two reinforcement learning algorithms (multi-agent and single-agent) developed in MATLAB R2021a were used for the weekly insulin recommendations of high-fat meals, postprandial exercise, and therapy parameters adjustments in the study. Both algorithms are described in details in the manuscript (though their pseudo codes provided in Algorithm 1 and Algorithm 2 tables inside the supplementary file) but the codes are proprietary intellectual property and thus cannot be made publicly available. Both algorithms cannot be used in routine practice, as regulatory approvals have not yet been granted. The glucose data from each participant were collected from the LibreView platform, while meals, insulin, and participant parameters data were collected from the Firebase server.
Data analysis	IBM SPSS statistics 28.0.1 was used for statistical analysis. The programs used for data analysis is shared in the Zenodo repository https://zenodo.org/records/12693079

For manuscripts utilizing custom algorithms or software that are central to the research but not yet described in published literature, software must be made available to editors and reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Portfolio guidelines for submitting code & software for further information.

Data

Policy information about availability of data

All manuscripts must include a data availability statement. This statement should provide the following information, where applicable:

- Accession codes, unique identifiers, or web links for publicly available datasets
- A description of any restrictions on data availability
- For clinical datasets or third party data, please ensure that the statement adheres to our policy

Source data are provided with this paper. The study protocol is provided with the submission. The raw individual data (e.g., glucose levels, meals, and insulin doses) collected during the trial cannot be made available publicly since they can only be used for the purposes stated in the participants' consent form. The raw data can be shared by the corresponding author without cost, for non-commercial purposes, subject to a material transfer agreement and approval by the Advarra Ethics Board. Upon agreement and approval, reasonable efforts will be made to share the requested data within 4 months of requests.

Research involving human participants, their data, or biological material

Policy information about studies with human participants or human data. See also policy information about sex, gender (identity/presentation), and sexual orientation and race, ethnicity and racism.

Reporting on sex and gender	In this study, there were 6 females and 9 males; we did not collect data on gender. Due to small sample size, we did not conduct a sex-based sub analysis.
Reporting on race, ethnicity, or other socially relevant groupings	In this study, we did not collect data on race, ethnicity, or other socially relevant groupings. In the study analysis, we used two confounding variables: participant ID and intercept in the linear-mixed model. We also did additional linear mixed model analysis (shown in Tables S1 and S4) in which we incorporated two more variables, age and sex.
Population characteristics	Participants characteristics were: 40% were female, age was 38±13 years, weight was 85±12 kg, BMI was 28±3 kg/m2, HbA1c was 8.5±1.1% (69±8 mmol/mol), duration of diabetes was 20±12 years, and total daily insulin was 52±17U.
Recruitment	Participants were recruited at the Clinique Medicale Hygea (Montreal, Canada). Participants from our past studies were contacted if they previously provided written consent. The written informed consent was obtained from each participant before enrollment. The study compensation of 300 CAD was provided to each participant.
Ethics oversight	The study was reviewed and approved by the Advarra Ethics Board.

Note that full information on the approval of the study protocol must also be provided in the manuscript.

Field-specific reporting

Please select the one below that is the best fit for your research. If you are not sure, read the appropriate sections before making your selection.

☒ Life sciences ☐ Behavioural & social sciences ☐ Ecological, evolutionary & environmental sciences

For a reference copy of the document with all sections, see nature.com/documents/nr-reporting-summary-flat.pdf

Life sciences study design

All studies must disclose on these points even when the disclosure is negative.

Sample size	Since this is an exploratory study, we did not perform power calculations for the sample size. Instead, we recruited 15 participants with type 1 diabetes to participate in this study.
Data exclusions	One participant out of 15 withdrew after 2 weeks due to a schedule conflict therefore the final sample size for the analysis was 14.
Replication	No attempt to replicated the findings were made. This would require a new clinical trial.
Randomization	This is a single-arm study so no randomization was performed.
Blinding	This is a single-arm study so no blinding was performed.

Reporting for specific materials, systems and methods

We require information from authors about some types of materials, experimental systems and methods used in many studies. Here, indicate whether each material, system or method listed is relevant to your study. If you are not sure if a list item applies to your research, read the appropriate section before selecting a response.

Materials & experimental systems

n/a	Involved in the study
☒	☐ Antibodies
☒	☐ Eukaryotic cell lines
☒	☐ Palaeontology and archaeology
☒	☐ Animals and other organisms
☐	☒ Clinical data
☒	☐ Dual use research of concern
☒	☐ Plants

Methods

n/a	Involved in the study
☒	☐ ChIP-seq
☒	☐ Flow cytometry
☒	☐ MRI-based neuroimaging

Clinical data

Policy information about clinical studies

All manuscripts should comply with the ICMJE guidelines for publication of clinical research and a completed CONSORT checklist must be included with all submissions.

Clinical trial registration	NCT05041621
Study protocol	The study protocol is provided during the first submission.
Data collection	All data were collected at the Clinique Medicale Hygea from July 2021 to February 2023.
Outcomes	As this is a pilot study, all outcomes are exploratory, and include (i) a comparison between the evaluation period (last four weeks of the available high-fat meals data) versus the baseline period (first three weeks of the available high-fat meal data) in 5-hour postprandial incremental area under the sensor glucose levels curve after high-fat meals, (ii) a comparison between the evaluation period (last 3 weeks of the available exercise data) versus the baseline period (the period, capped at 4 weeks, where the algorithm's recommendations ≤ 20% of the initial values) in 5-hour postprandial incremental area under the sensor glucose levels curve after meals followed by postprandial aerobic exercise events, and (iii) change in an HbA1c from baseline, and (iv) the percentage of time that the sensor glucose readings were in the target range (3.9–10.0 mmol/L), above target range, and below target range. Other endpoints for high-fat meals, meals followed by postprandial aerobic exercises, and 24-h outcomes include (i) percentage time spent with glucose levels below target ranges (<3.9 mmol/L, <3.3 mmol/L, <2.8 mmol/L), in different target ranges (between 3.9-10 mmol/L and between 3.9-7.8 mmol/L), and above target ranges (>7.8 mmol/L, >10 mmol/L, >13.9 mmol/L, and >16.7 mmol/L), (ii) mean glucose, standard deviation, and coefficient of variation, (iii) the 5-hour postprandial incremental area under the sensor glucose levels after all meals , and (iv) mean scores of the survey items on the modified versions of the DTSQ, HFS-II and MAUQ.

Plants

Seed stocks	Not Applicable
Novel plant genotypes	Not Applicable
Authentication	Not Applicable