# Personalised adaptive basal-bolus algorithm using SMBG/CGM data

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MyTreat
A Mobile Platform for Personalization of Insulin Delivery based on a Patch Pump and Reinforcement Learning

## Background and Aims

An essential component of the diabetes management plan is the glucose monitoring using either meters for self-monitoring of blood glucose (SMBG) or more recently continuous glucose monitors (CGM).

The main objective of the study is the **simultaneous personalisation of the basal and bolus insulin** to be delivered by a pump **independent of the used glucose monitoring device (SMBG or CGM)** using a newly proposed **adaptive basal-bolus algorithm (ABBA)**.

## Method

ABBA is based on reinforcement learning (RL), a branch of artificial intelligence algorithms, that

***"….allows the system to learn its behaviour based on feedback from the environment"***

After an initialization phase of seven days using patient's CGM and insulin pump data the ABBA estimates the basal and bolus independently if he/she is using CGM or SMBG.

**ABBA**

**Input:** Glucose concentrations (from SMBG or CGM) of day *i*

**Output:** Basal rate for day *i*+1, and three Carbohydrate to Insulin Ratios (CIRs) for
- breakfast - $CIR_B$,
- lunch - $CIR_L$, and
- dinner - $CIR_D$

for the day *i*+1

## In silico evaluation and daily scenario

The training version of the FDA accepted UVa/Padova T1DM Simulator v3.2

- The scenario lasted for 98 days (Days 2-8 for initialization; Days 9-98 for control).
- Three meals (breakfast, lunch and dinner) were considered with variabilities in the announcement of mealtime (±15 min) and carbohydrate amount (±10g for main meals and ±5g for snack). In addition, an uncertainty in the order of ±50% was introduced to simulate the error of patient's carbohydrate content self-estimations.
- Variable insulin sensitivity (dawn phenomenon -50% from 4:00 AM to 8:00 AM and interday variability in the order of ±25%).

Both variabilities and uncertainties follow uniform distributions.

## Results

| | BG (mg/dL) | % in target range | % in Hypo | % in Hyper | Total daily insulin (U) |
|---|---|---|---|---|---|
| | *(mean ± standard deviation)* | | | | |
| **Adults** | | | | | |
| $ABBA_{CGM}$ | 140.9 ± 18.4 | 87.5 ± 16.1 | 1.0 ± 1.1 | 11.5 ± 15.4 | 43.2 ± 10.8 |
| $ABBA_{SMBG}$ | 143.5 ± 18.9 | 86.9 ± 16.7 | 0.6 ± 0.9 | 12.5 ± 16.0 | 42.6 ± 9.9 |
| **Adolescents** | | | | | |
| $ABBA_{CGM}$ | 148.1 ± 11.5 | 75.7 ± 12.2 | 2.4 ± 2.0 | 21.9 ± 12.3 | 31.6 ± 6.7 |
| $ABBA_{SMBG}$ | 145.8 ± 9.3 | 77.8 ± 13.6 | 2.6 ± 2.2 | 19.6 ± 12.7 | 31.8 ± 7.1 |
| **Children** | | | | | |
| $ABBA_{CGM}$ | 149.3 ± 9.0 | 75.0 ± 9.8 | 1.8 ± 1.6 | 23.2 ± 8.8 | 15.9 ± 3.8 |
| $ABBA_{SMBG}$ | 150.5 ± 10.8 | 75.2 ± 12.4 | 1.1 ± 1.3 | 23.7 ± 11.5 | 15.9 ± 3.7 |

*No statistically significant difference was observed between $ABBA_{CGM}$ and $ABBA_{SMBG}$, $\alpha$=0.05*
*Target range: [70 180] mg/dl; Hypo < 70 mg/dl; Hyper > 180 mg/dl*

## Conclusions

ABBA, the proposed RL algorithm, demonstrated its ability to achieve

- glucose control in an *in silico* population using a complex scenario characterized by a high degree of variabilities and uncertainties,
- comparable performances for both CGM and SMBG, without affecting the total daily insulin dose.

***Next step***

ABBA within the framework of a clinical study

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