INTRODUCTION:
We investigate the application of Linear Quadratic Gaussian (LQG) control methodology to the SC-SC blood glucose regulation problem. We evaluate, in silico, subject-specific LQG control and compare to a pre-existing PID controller [Steil et al., Diabetes 55, 2006].

METHODS:
Based on a linearization of the T1DM model [Dalla Man et al., JDST, 2007], our LQG controller infuses insulin to minimize squared deviations from a nominal target, including glucose concentration and basal insulin rate. A Kalman filter estimates metabolic states based on CGM, and the insulin infusion is computed from LQR feedback gains applied to these estimates.

The evaluation of LQG and comparison to PID was performed in a simulation environment including physiological and technological models (e.g. CGM sensor). Results are presented for 4 classical indices of glucose control:
- PERCH (percent-time BG>180mg/dl)
- PERCVL (percent-time BG<70mg/dl)
- LBGI
- Min_gli (minimum glycemia).

The gains of the PID controller, along with the computation of the proportional, integral, and derivative signals, are implemented as closely to the methodology of [Steil et al., Diabetes 55, 2006] as possible, using the T1DM simulation to assess subject-specific metabolic parameters, as needed. Our simulation protocol followed that of [Steil et al., Diabetes 55, 2006].

RESULTS:
Results from 10 independent trials with 100 in-silico subjects (1000 total trials) are shown in Table 1., with the LQG target adjusted to match PID average glycemia. Note that the subjects spent less time in hyperglycemia on average (p < .001) under PID control, compared to LQG. On the other hand, the LQG controller achieved much lower hypoglycemic excursions, with smaller average PERCVL (p < .001), smaller average LBGI (p < .001), and higher min_BG on average (p < .001). Average glycemia for the PID controller was 128.2 (mg/dl), while the average glycemia for the LQG controller was 128.7, not significantly different (p = .65).

CONCLUSIONS:
LQG control achieves tight glycemic regulation with minimum hypoglycemic events in silico. Overall, LQG compares favorably to PID: equal average BG, comparable maximum and lower risk of hypoglycemia. Postprandial excursions were comparable in both methods, hinting at limitations of purely reactive methods.