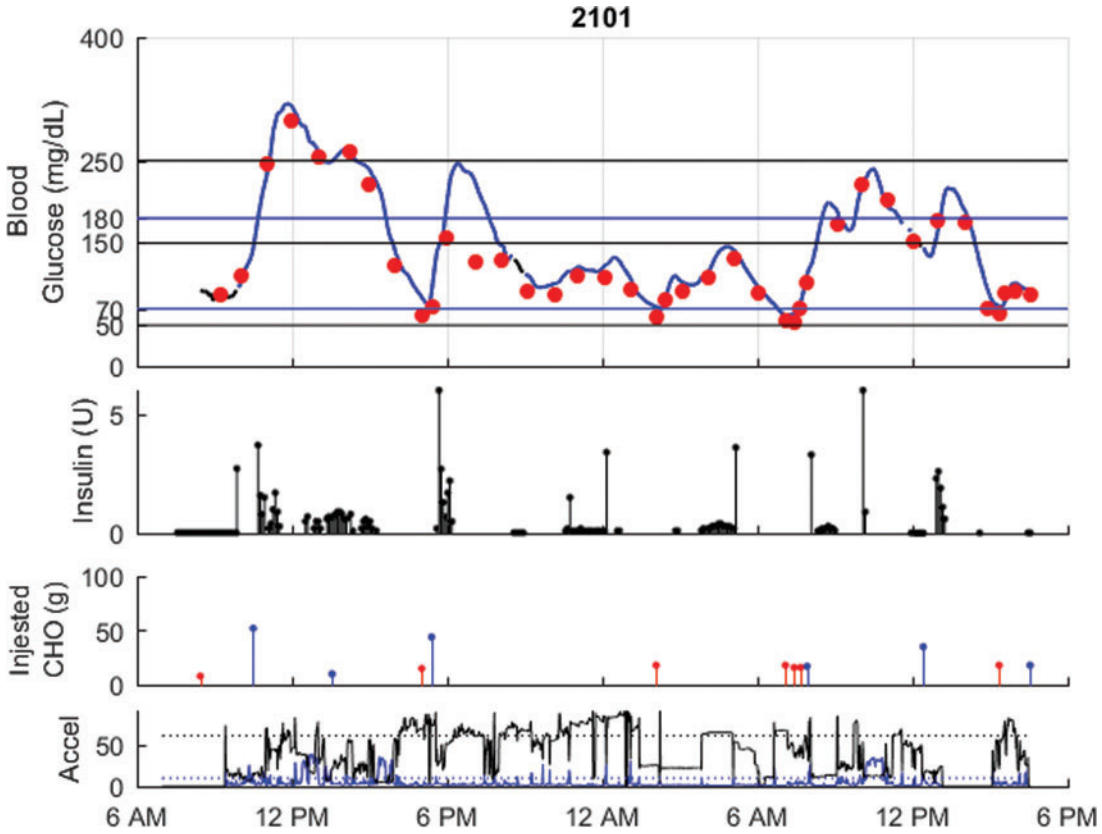
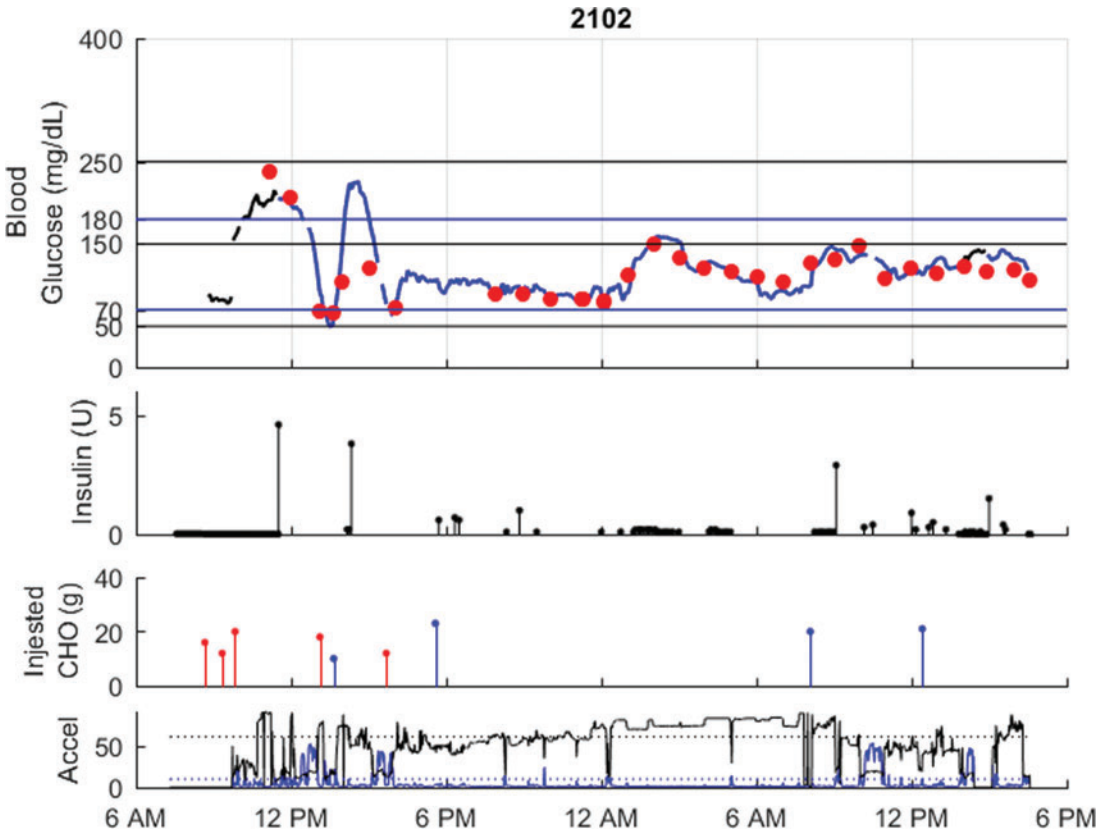
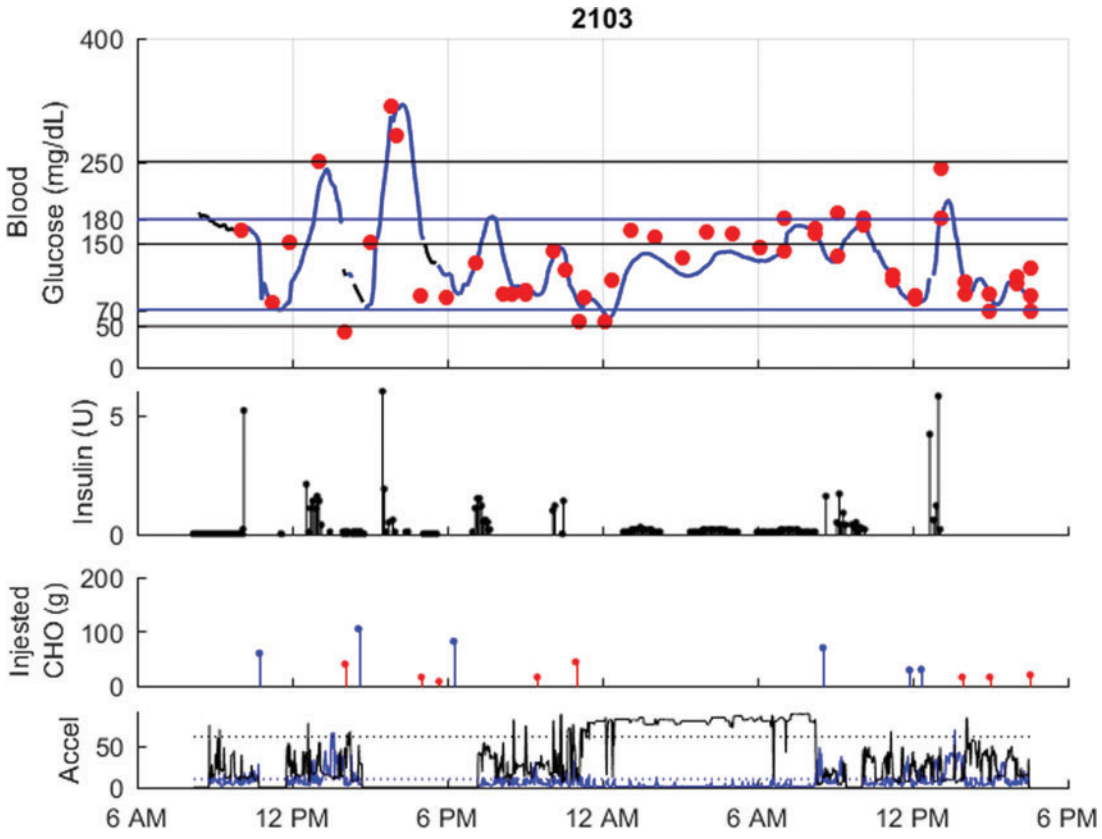
Supplementary Data



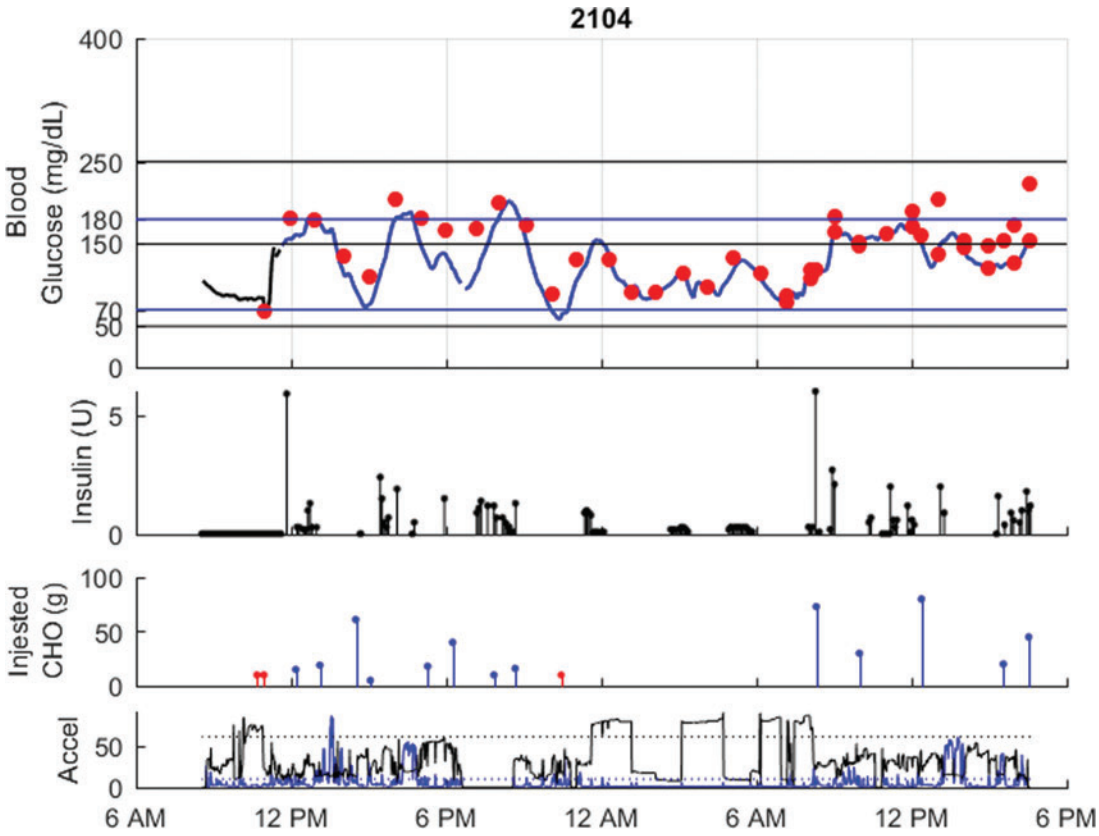
SUPPLEMENTARY FIG. S1. Closed-loop performance for subject 2101. Top: Glucose, CGM (black, before CL; blue, during CL), Ref (solid circles). Second: Insulin delivered. Third: Carbs, intervention (red) and meals (blue). Bottom: Accelerometer orientation (black, >60 indicates sleep) and activity (blue, >10 indicates exercise). This subject started with low blood glucose, requiring carbohydrates at 9:30 AM, before closed loop. Detecting sleep using an accelerometer worked poorly, leading to periods of inappropriately concentrated insulin dosing and two bouts of hypoglycemia overnight.



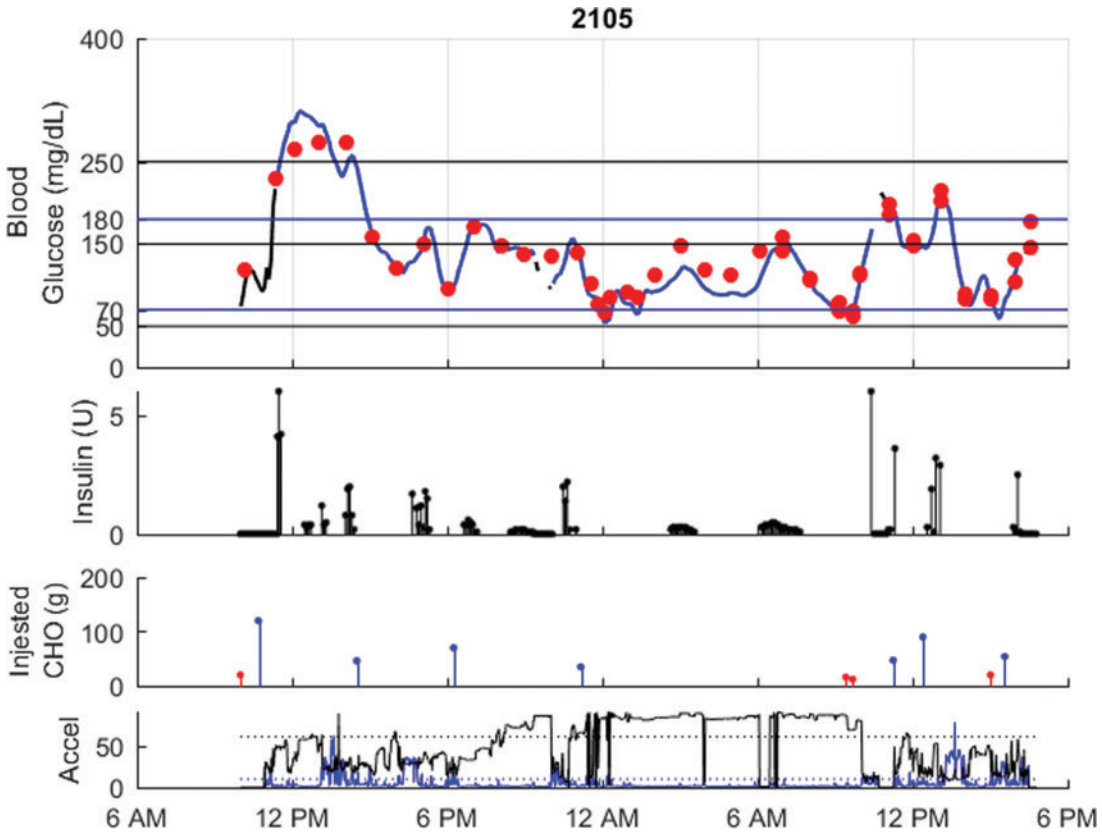
SUPPLEMENTARY FIG. S2. Closed-loop performance for subject 2102. Top: Glucose, CGM (black, before CL; blue, during CL), Ref (solid circles). Second: Insulin delivered. Third: Carbs, intervention (red) and meals (blue). Bottom: Accelerometer orientation (black, >60 indicates sleep) and activity (blue, >10 indicates exercise). Subject 2102 normal carbohydrate consumption intentionally averaged 30 g/day. She entered the study low, yet with a high ketone level due to the diet. This required both a carb treatment and insulin, thus the three carb ingestions at around 8:30 AM, as shown in Figure 2. Since the controller was not told about the insulin taken to cover the carbs, it was too aggressive.



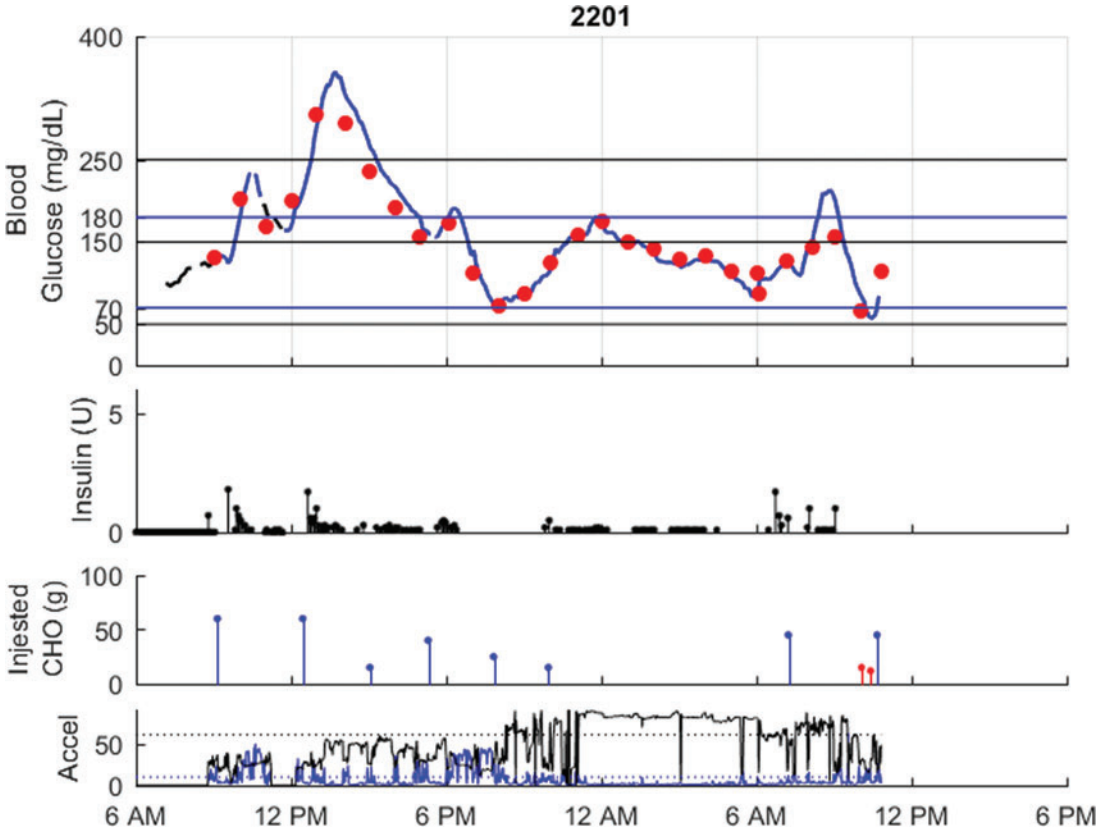
SUPPLEMENTARY FIG. S3. Closed-loop performance for subject 2103. Top: Glucose, CGM (black, before CL; blue, during CL), Ref (solid circles). Second: Insulin delivered. Third: Carbs, intervention (red) and meals (blue). Bottom: Accelerometer orientation (black, >60 indicates sleep) and activity (blue, >10 indicates exercise). Subject 2103 experienced very fast rises and falls around meals. This likely caused the controller to overestimate the meal sizes. This patient oscillated into hypoglycemia seven times over the 2-day time periods.



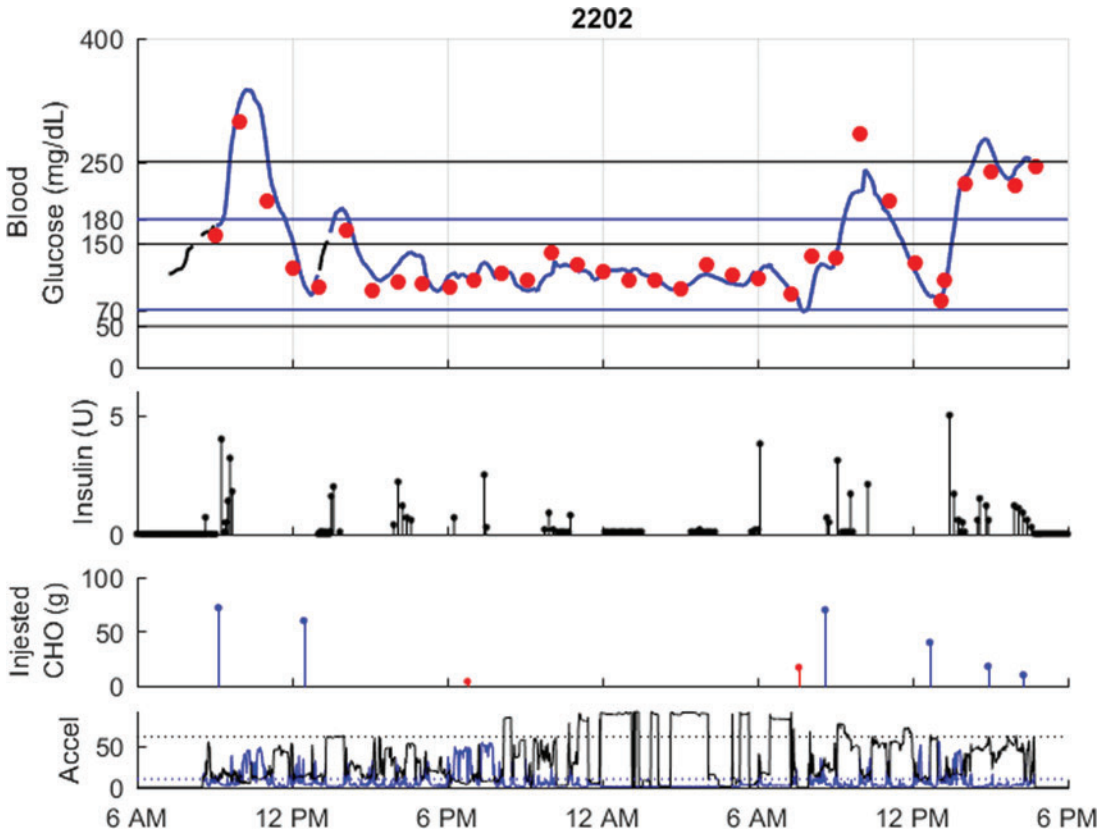
SUPPLEMENTARY FIG. S4. Closed-loop performance for subject 2104. Top: Glucose, CGM (black, before CL; blue, during CL), Ref (solid circles). Second: Insulin delivered. Third: Carbs, intervention (red) and meals (blue). Bottom: Accelerometer orientation (black, >60 indicates sleep) and activity (blue, >10 indicates exercise). Subject 2104 received treatment at 11 AM to bring glucose into range to close the loop.



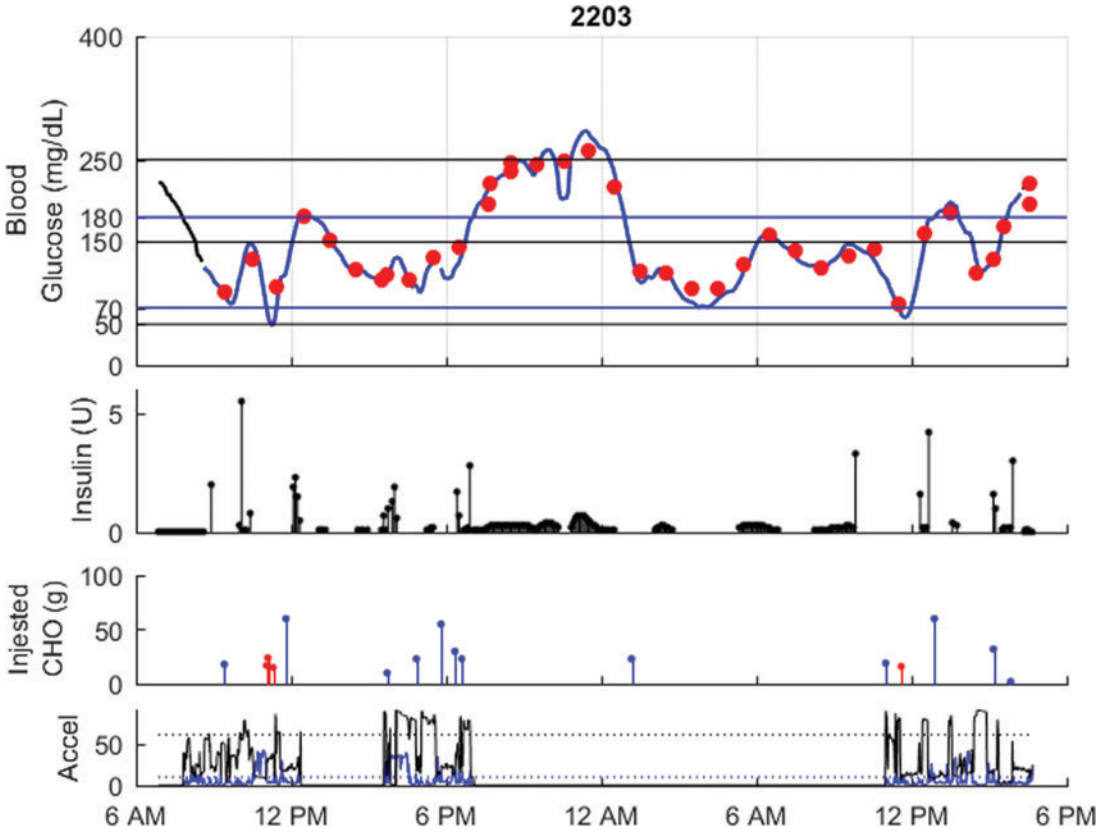
SUPPLEMENTARY FIG. S5. Closed-loop performance for subject 2105. Top: Glucose, CGM (black, before CL; blue, during CL), Ref (solid circles). Second: Insulin delivered. Third: Carbs, intervention (red) and meals (blue). Bottom: Accelerometer orientation (black, >60 indicates sleep) and activity (blue, >10 indicates exercise). Subject 2105 received carbs to bring glucose into range before closing the loop.



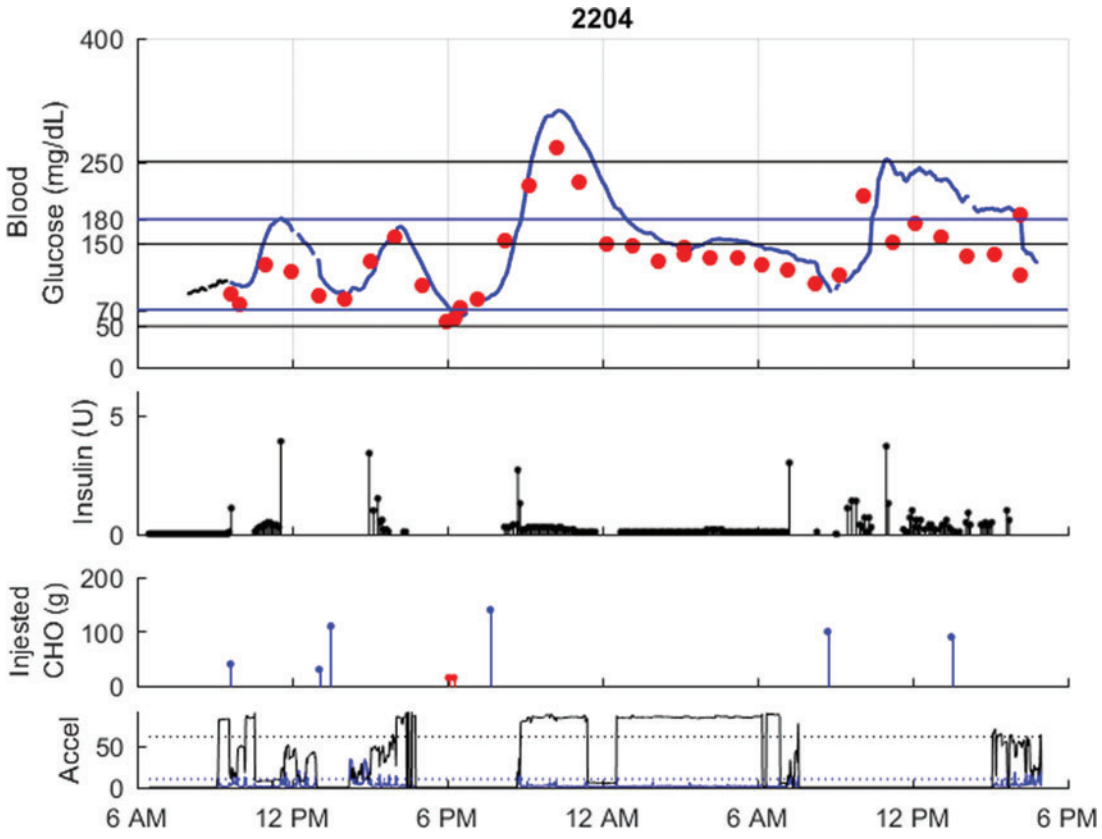
SUPPLEMENTARY FIG. S6. Closed-loop performance for subject 2201. Top: Glucose, CGM (black, before CL; blue, during CL), Ref (solid circles). Second: Insulin delivered. Third: Carbs, intervention (red) and meals (blue). Bottom: Accelerometer orientation (black, >60 indicates sleep) and activity (blue, >10 indicates exercise). Due to equipment malfunctions, subject 2201 spent a lot of time out of closed loop initially.



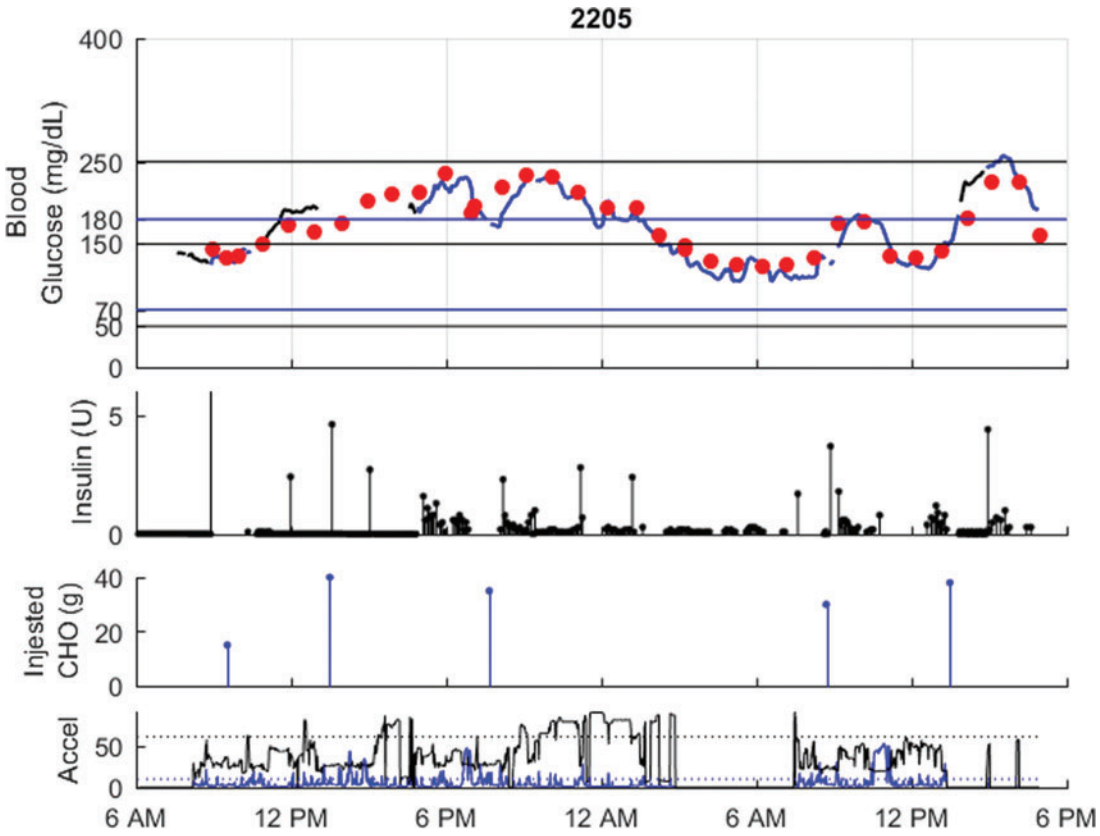
SUPPLEMENTARY FIG. S7. Closed-loop performance for subject 2202. Top: Glucose, CGM (black, before CL; blue, during CL), Ref (solid circles). Second: Insulin delivered. Third: Carbs, intervention (red) and meals (blue). Bottom: Accelerometer orientation (black, >60 indicates sleep) and activity (blue, >10 indicates exercise). This subject experienced a failure of the activity monitor to detect sleep leading to an inappropriately large bolus before breakfast on the second day.



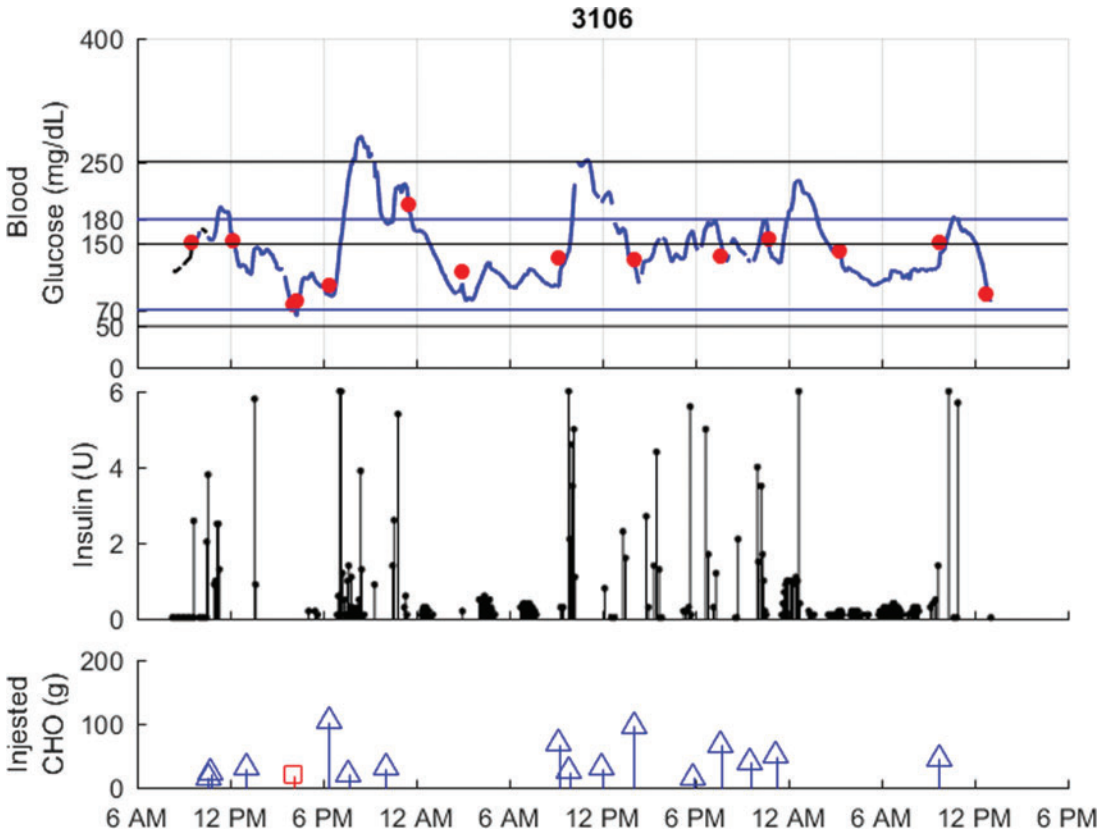
SUPPLEMENTARY FIG. S8. Closed-loop performance for subject 2203. Top: Glucose, CGM (black, before CL; blue, during CL), Ref (solid circles). Second: Insulin delivered. Third: Carbs, intervention (red) and meals (blue). Bottom: Accelerometer orientation (black, >60 indicates sleep) and activity (blue, >10 indicates exercise). The patient's basal rates were reset down to 53% of TDD (1.0 U/h) instead of 80% of TDD after the first hypoglycemic event. This individual went to sleep right after dinner on the first day blunting the response to dinner. She naturally woke up at 1 AM and snacked. A late wakeup the next day and an improperly set wakeup time led to an inappropriately large bolus at 9:30 AM and a hypoglycemic event.



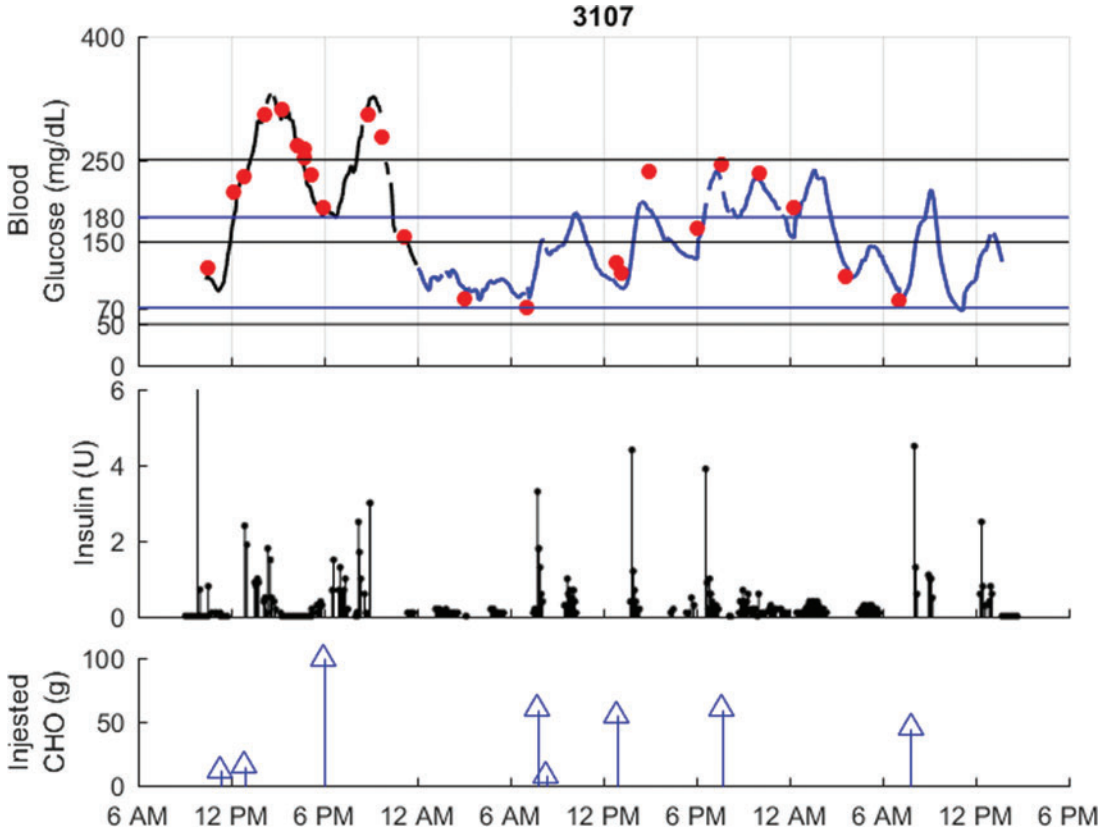
SUPPLEMENTARY FIG. S9. Closed-loop performance for subject 2204. Top: Glucose, CGM (black, before CL; blue, during CL), Ref (solid circles). Second: Insulin delivered. Third: Carbs, intervention (red) and meals (blue). Bottom: Accelerometer orientation (black, >60 indicates sleep) and activity (blue, >10 indicates exercise). Dinner was a carrot cake and a mountain dew.



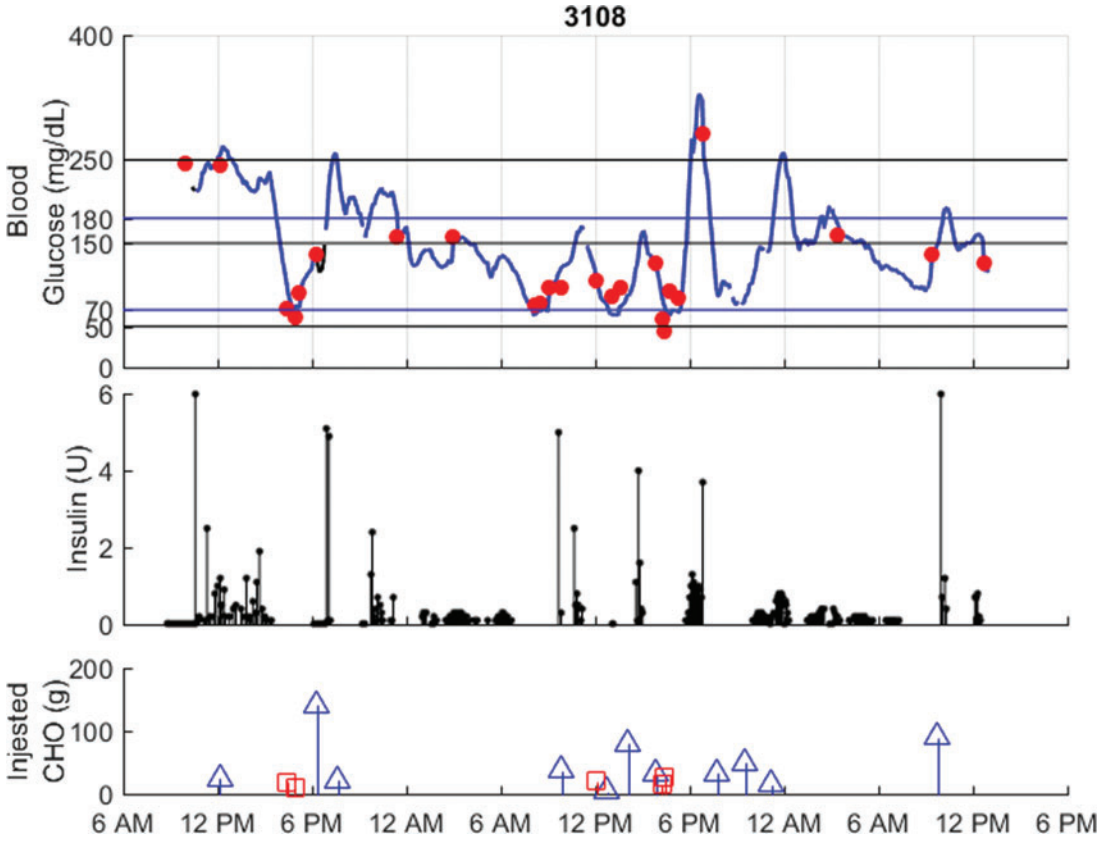
SUPPLEMENTARY FIG. S10. Closed-loop performance for subject 2205. Top: Glucose, CGM (black, before CL; blue, during CL), Ref (solid circles). Second: Insulin delivered. Third: Carbs, intervention (red) and meals (blue). Bottom: Accelerometer orientation (black, >60 indicates sleep) and activity (blue, >10 indicates exercise). The early breaks from closed loop were caused by equipment malfunctions.



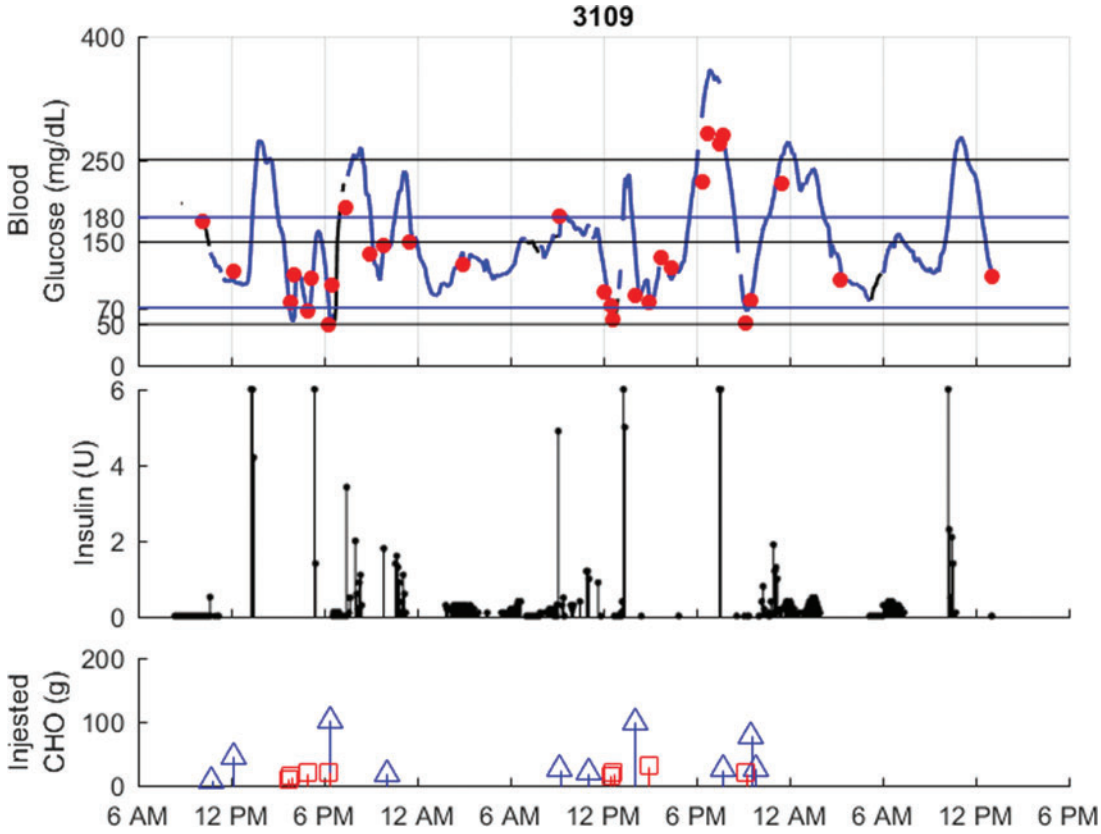
SUPPLEMENTARY FIG. S11. Closed-loop performance for subject 3106. Top: Glucose, CGM (black, before CL; blue, during CL), Ref (solid circles). Second: Insulin delivered. Third: Carbs, intervention (red) and meals (blue). Bottom: Accelerometer orientation (black, >60 indicates sleep) and activity (blue, >10 indicates exercise).



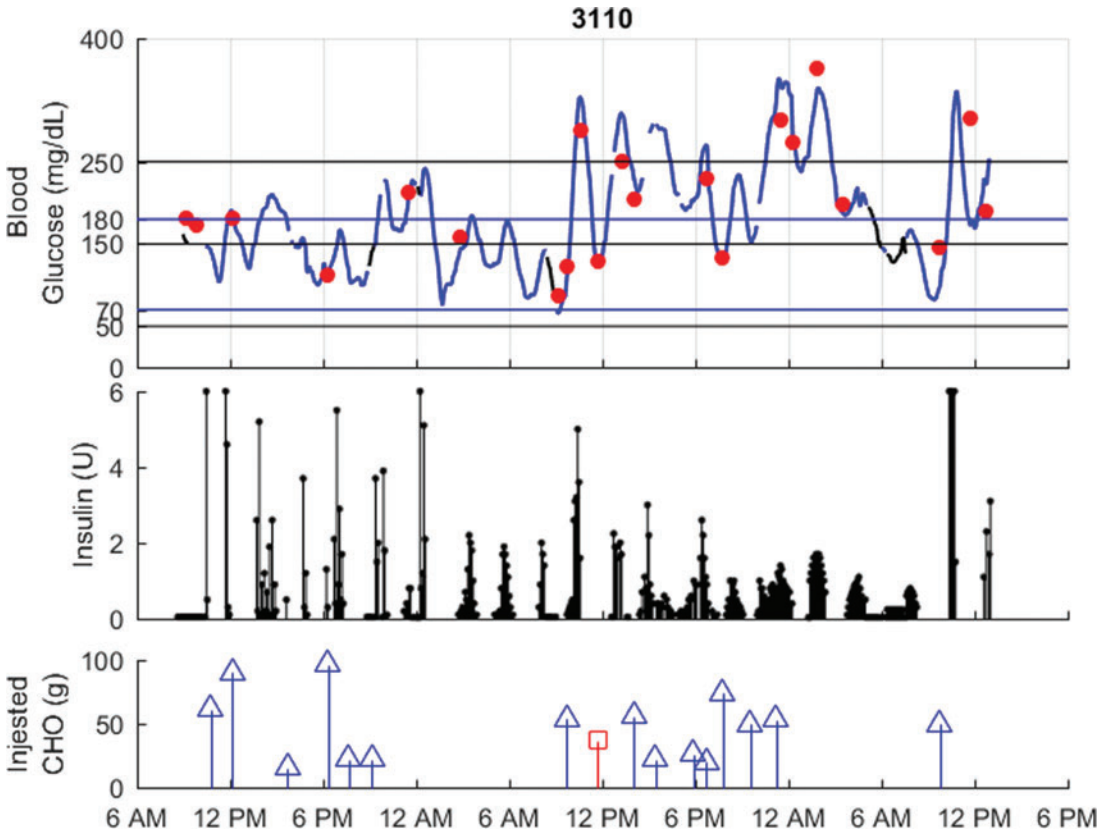
SUPPLEMENTARY FIG. S12. Closed-loop performance for subject 3107. Top: Glucose, CGM (black, before CL; blue, during CL), Ref (solid circles). Second: Insulin delivered. Third: Carbs, intervention (red) and meals (blue). Bottom: Accelerometer orientation (black, >60 indicates sleep) and activity (blue, >10 indicates exercise).



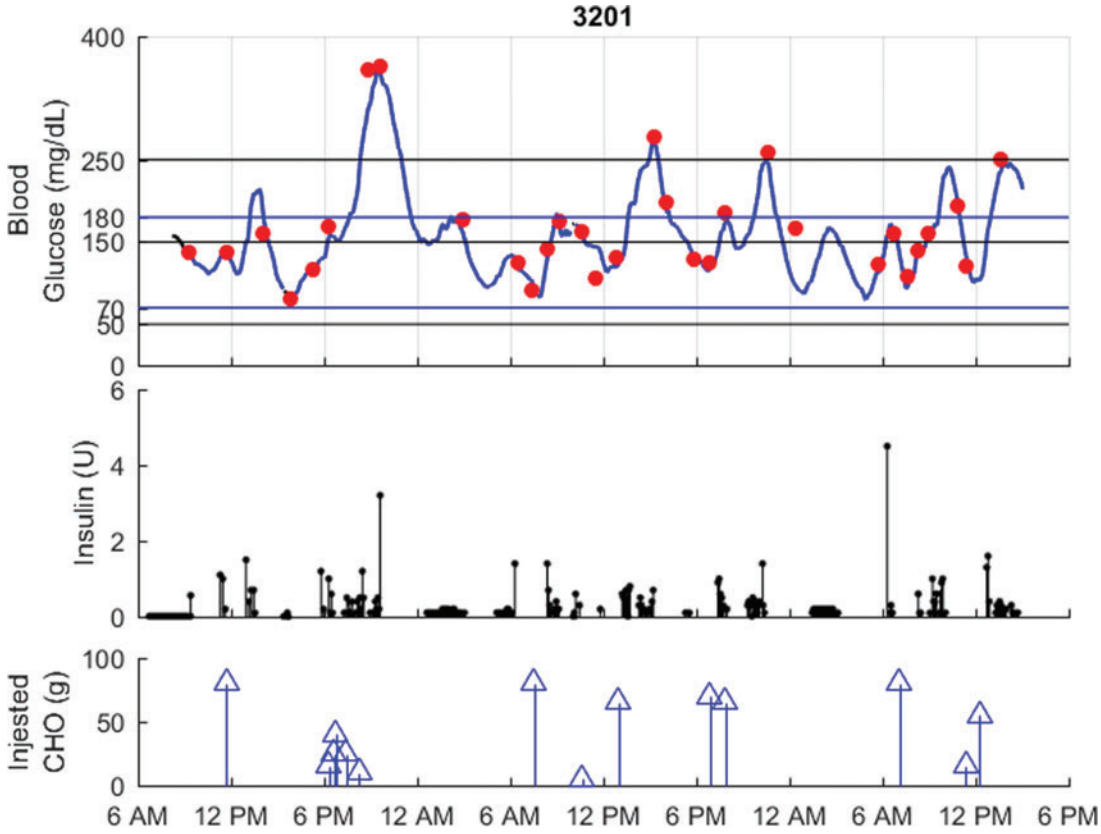
SUPPLEMENTARY FIG. S13. Closed-loop performance for subject 3108. Top: Glucose, CGM (black, before CL; blue, during CL), Ref (solid circles). Second: Insulin delivered. Third: Carbs, intervention (red) and meals (blue). Bottom: Accelerometer orientation (black, >60 indicates sleep) and activity (blue, >10 indicates exercise).



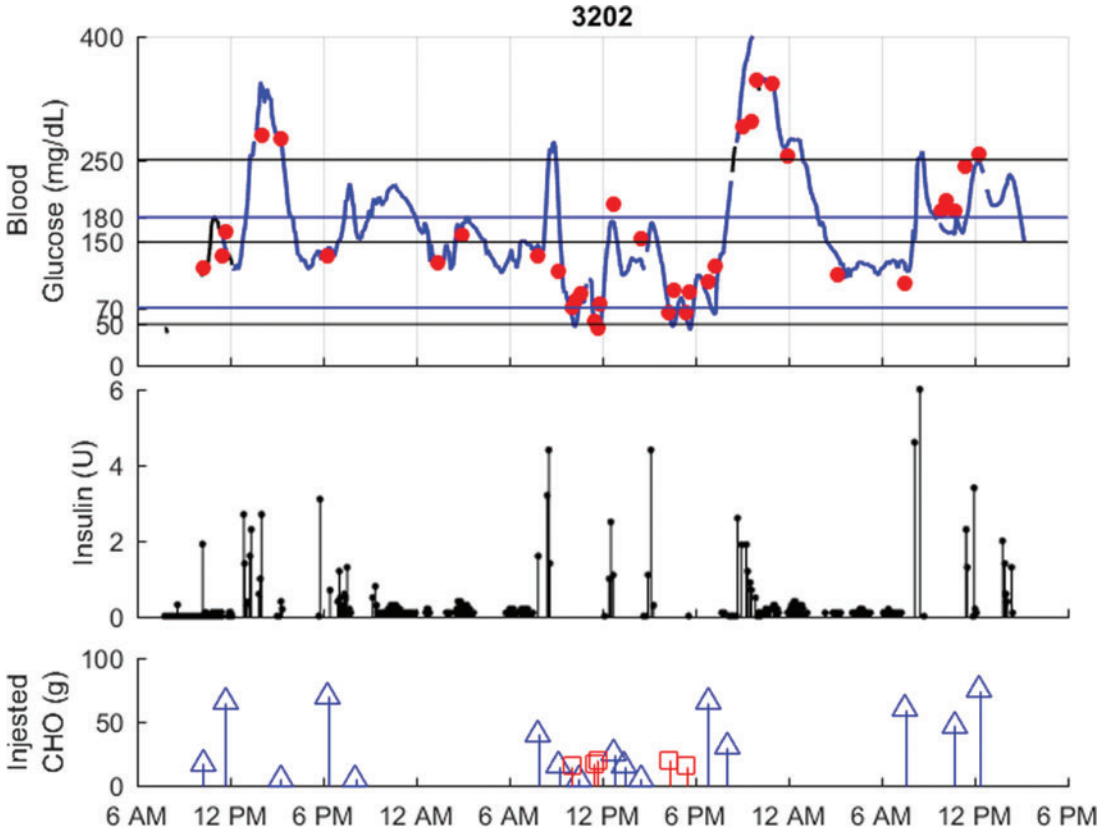
SUPPLEMENTARY FIG. S14. Closed-loop performance for subject 3109. Top: Glucose, CGM (black, before CL; blue, during CL), Ref (solid circles). Second: Insulin delivered. Third: Carbs, intervention (red) and meals (blue). Bottom: Accelerometer orientation (black, >60 indicates sleep) and activity (blue, >10 indicates exercise).



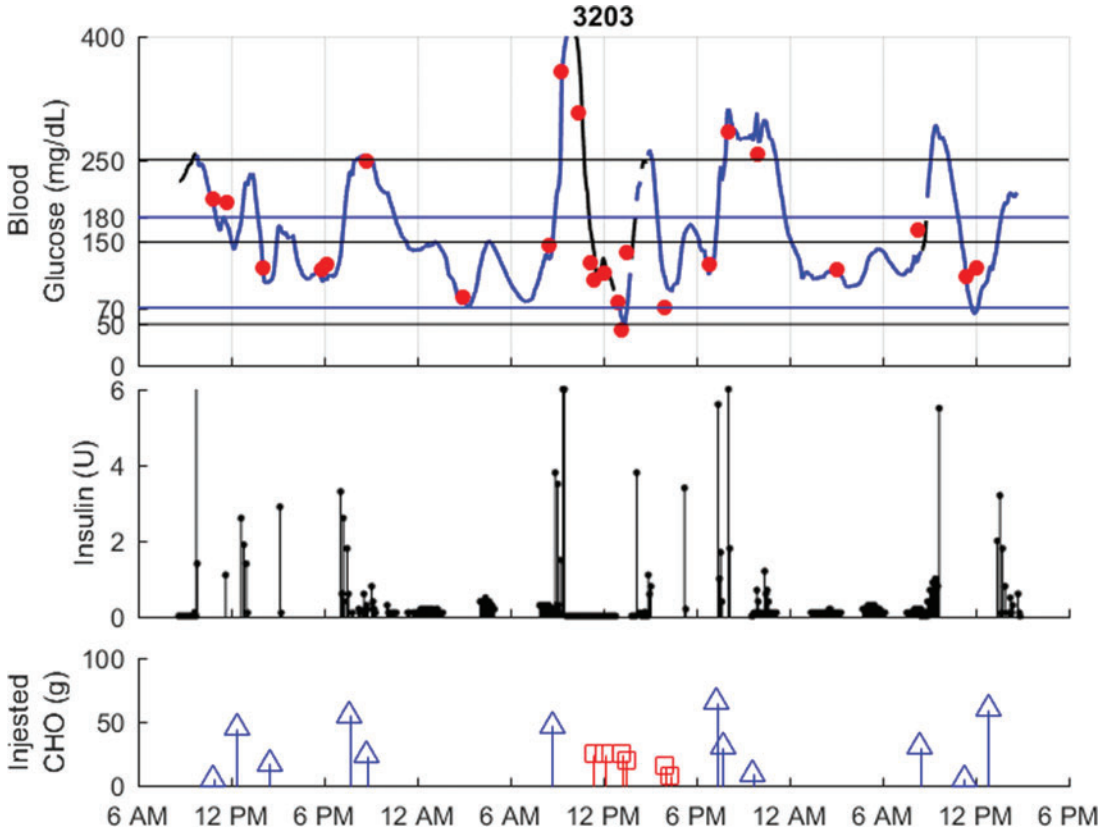
SUPPLEMENTARY FIG. S15. Closed-loop performance for subject 3110. Top: Glucose, CGM (black, before CL; blue, during CL), Ref (solid circles). Second: Insulin delivered. Third: Carbs, intervention (red) and meals (blue). Bottom: Accelerometer orientation (black, >60 indicates sleep) and activity (blue, >10 indicates exercise).



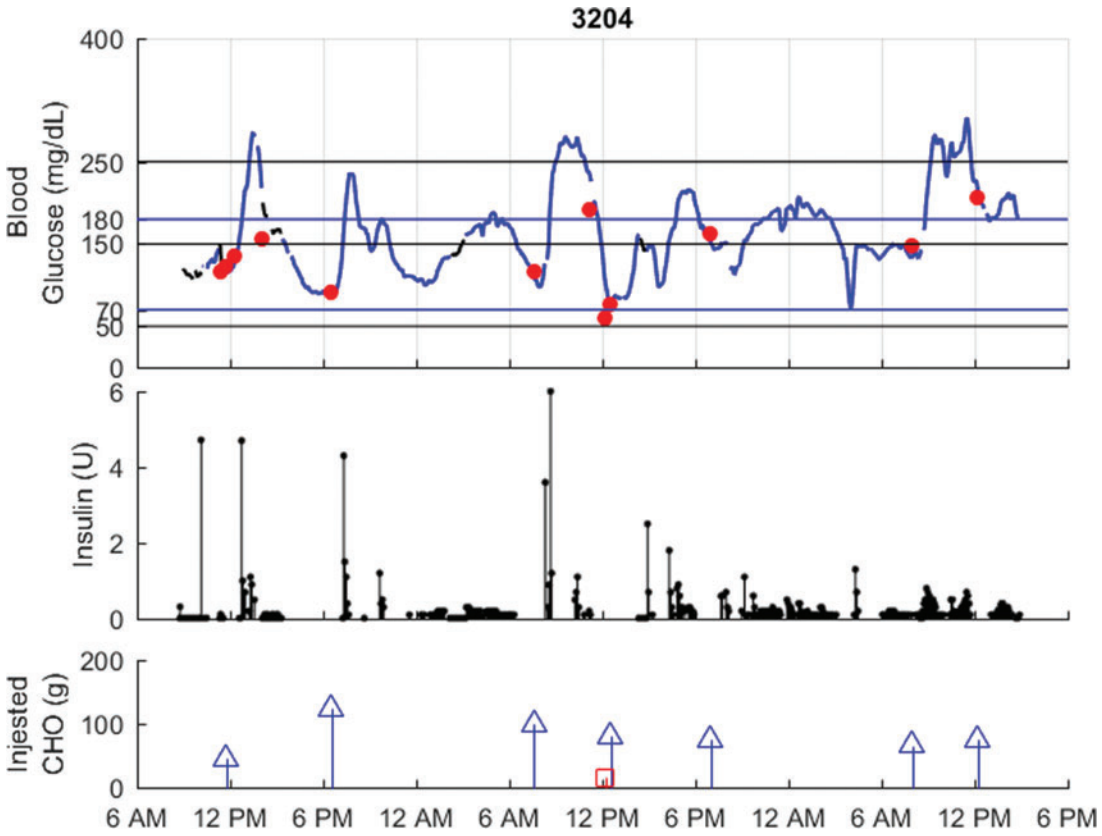
SUPPLEMENTARY FIG. S16. Closed-loop performance for subject 3201. Top: Glucose, CGM (black, before CL; blue, during CL), Ref (solid circles). Second: Insulin delivered. Third: Carbs, intervention (red) and meals (blue). Bottom: Accelerometer orientation (black, >60 indicates sleep) and activity (blue, >10 indicates exercise).



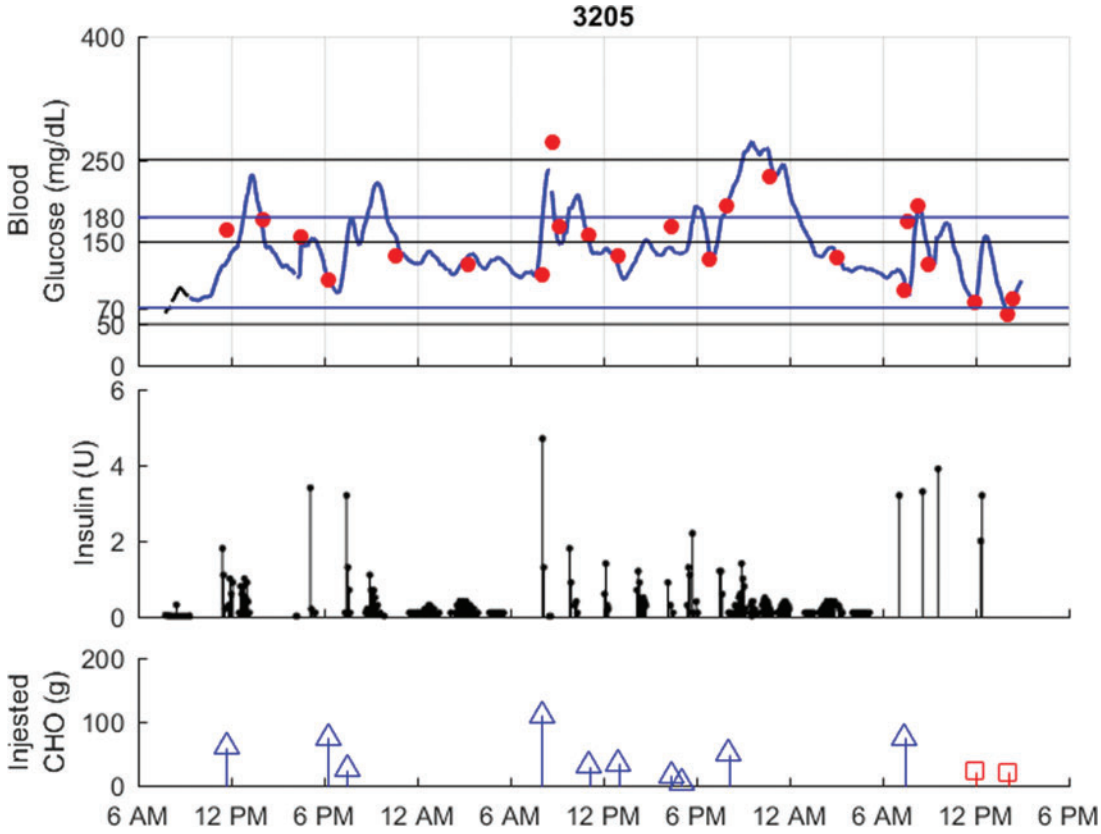
SUPPLEMENTARY FIG. S17. Closed-loop performance for subject 3202. Top: Glucose, CGM (black, before CL; blue, during CL), Ref (solid circles). Second: Insulin delivered. Third: Carbs, intervention (red) and meals (blue). Bottom: Accelerometer orientation (black, >60 indicates sleep) and activity (blue, >10 indicates exercise).



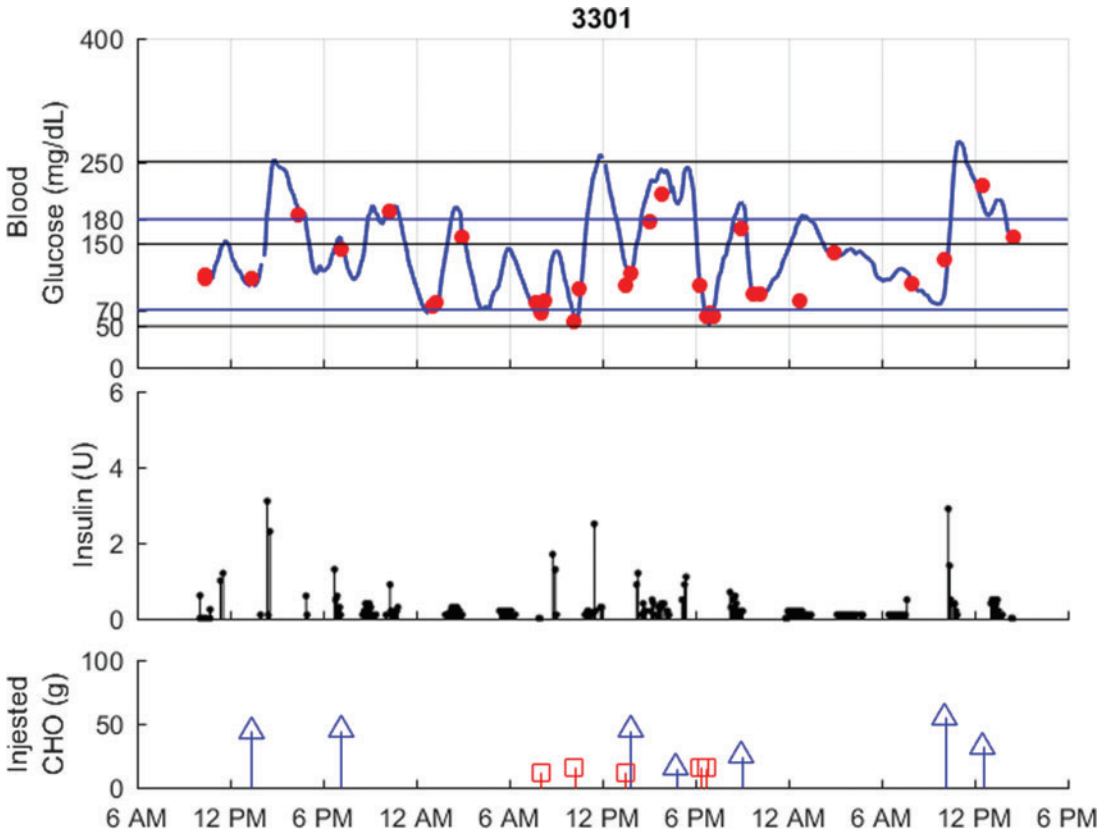
SUPPLEMENTARY FIG. S18. Closed-loop performance for subject 3203. Top: Glucose, CGM (black, before CL; blue, during CL), Ref (solid circles). Second: Insulin delivered. Third: Carbs, intervention (red) and meals (blue). Bottom: Accelerometer orientation (black, >60 indicates sleep) and activity (blue, >10 indicates exercise). At the second breakfast, a calibration was entered into the Dexcom with a rapid rate of change that was not communicated to the controller. This led to a large overestimation of the meal size and too much insulin delivery.



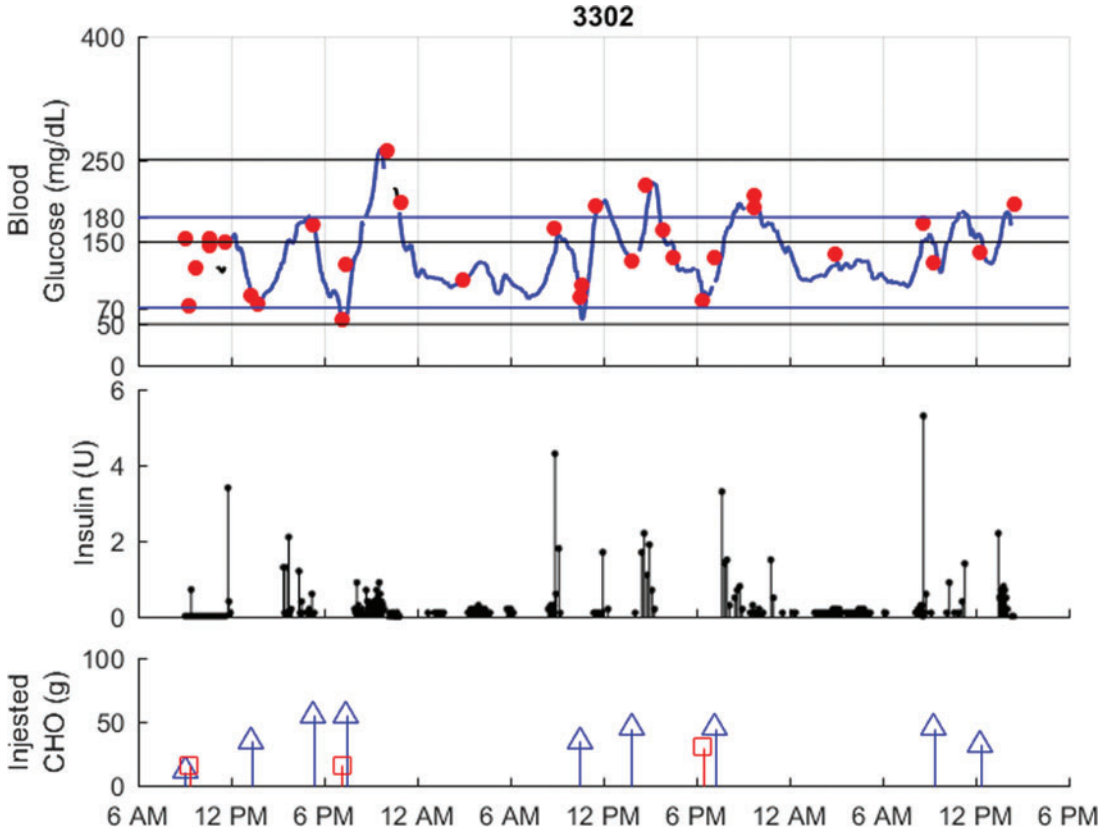
SUPPLEMENTARY FIG. S19. Closed-loop performance for subject 3204JB. Top: Glucose, CGM (black, before CL; blue, during CL), Ref (solid circles). Second: Insulin delivered. Third: Carbs, intervention (red) and meals (blue). Bottom: Accelerometer orientation (black, >60 indicates sleep) and activity (blue, >10 indicates exercise).



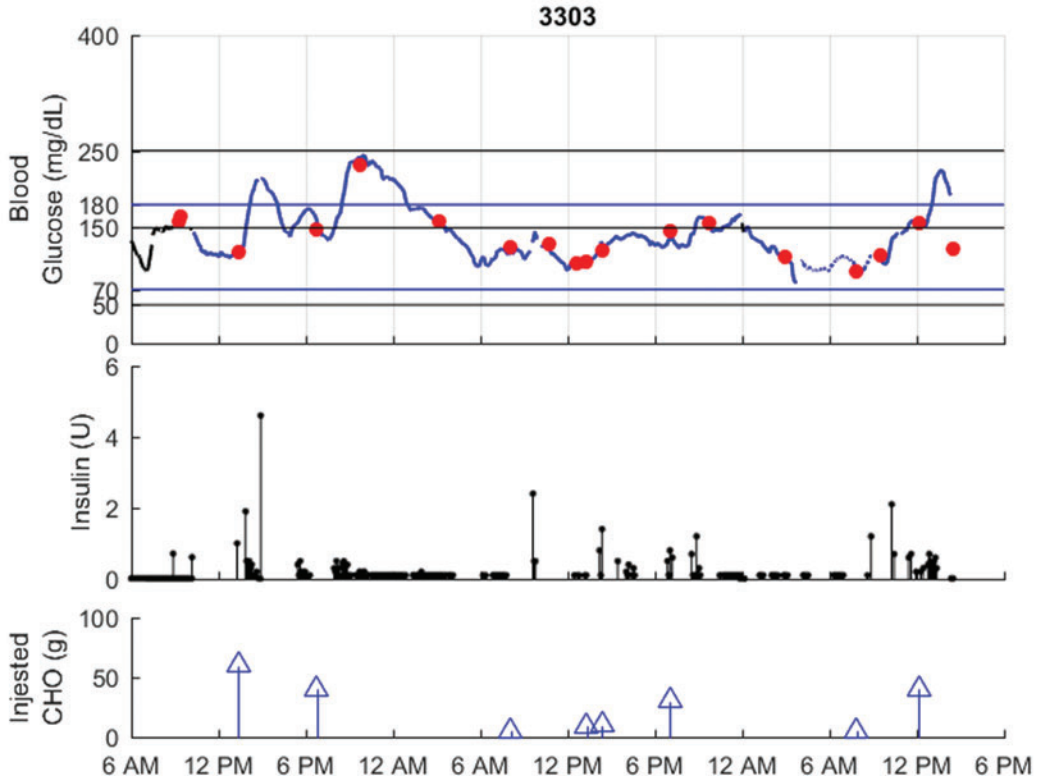
SUPPLEMENTARY FIG. S20. Closed-loop performance for subject 3205KK. Top: Glucose, CGM (black, before CL; blue, during CL), Ref (solid circles). Second: Insulin delivered. Third: Carbs, intervention (red) and meals (blue). Bottom: Accelerometer orientation (black, >60 indicates sleep) and activity (blue, >10 indicates exercise).



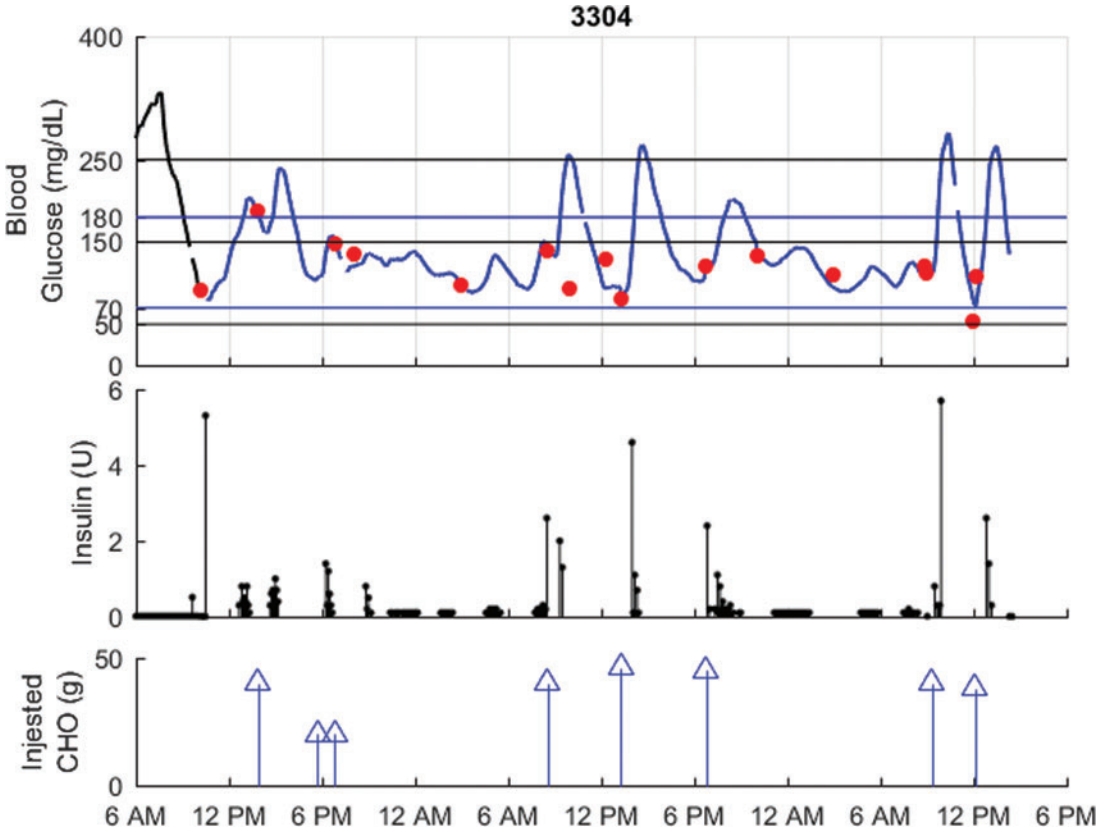
SUPPLEMENTARY FIG. S21. Closed-loop performance for subject 3301. Top: Glucose, CGM (black, before CL; blue, during CL), Ref (solid circles). Second: Insulin delivered. Third: Carbs, intervention (red) and meals (blue). Bottom: Accelerometer orientation (black, >60 indicates sleep) and activity (blue, >10 indicates exercise).



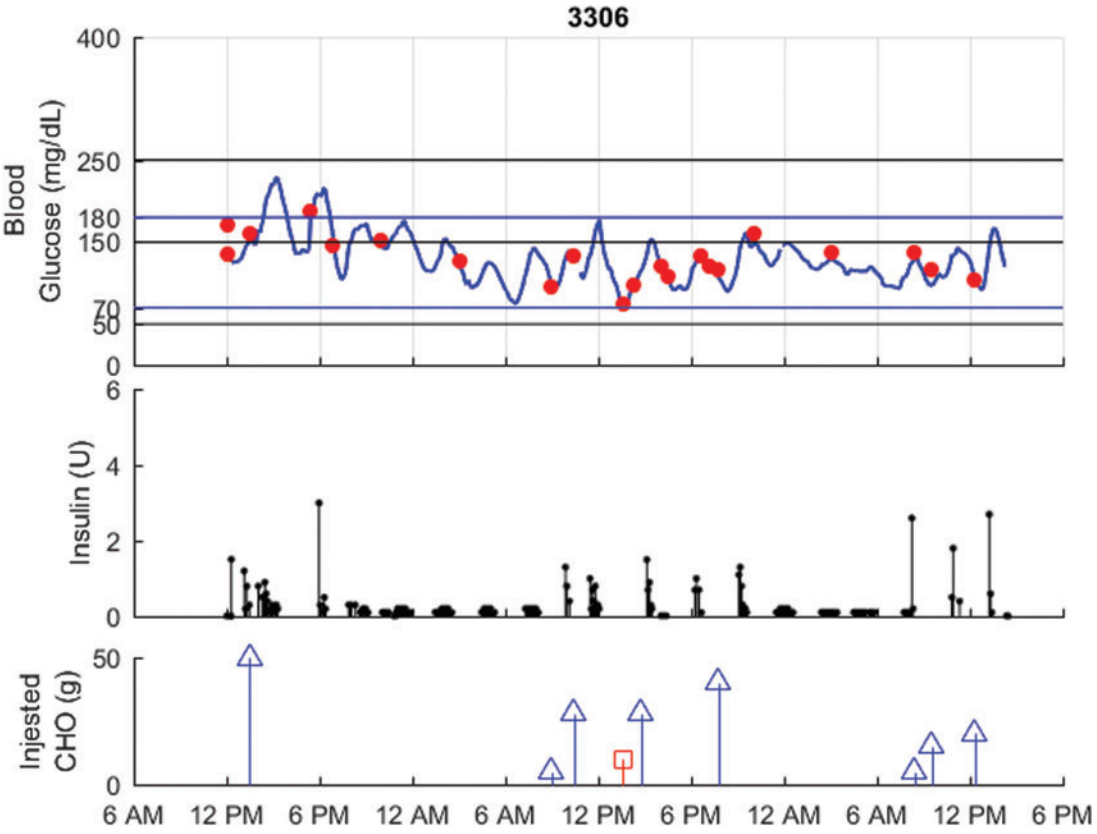
SUPPLEMENTARY FIG. S22. Closed-loop performance for subject 3302. Top: Glucose, CGM (black, before CL; blue, during CL), Ref (solid circles). Second: Insulin delivered. Third: Carbs, intervention (red) and meals (blue). Bottom: Accelerometer orientation (black, >60 indicates sleep) and activity (blue, >10 indicates exercise).



SUPPLEMENTARY FIG. S23. Closed-loop performance for subject 3303. Top: Glucose, CGM (black, before CL; blue, during CL), Ref (solid circles). Second: Insulin delivered. Third: Carbs, intervention (red) and meals (blue). Bottom: Accelerometer orientation (black, >60 indicates sleep) and activity (blue, >10 indicates exercise).



SUPPLEMENTARY FIG. S24. Closed-loop performance for subject 3304. Top: Glucose, CGM (black, before CL; blue, during CL), Ref (solid circles). Second: Insulin delivered. Third: Carbs, intervention (red) and meals (blue). Bottom: Accelerometer orientation (black, >60 indicates sleep) and activity (blue, >10 indicates exercise).



SUPPLEMENTARY FIG. S25. Closed-loop performance for subject 3306. Top: Glucose, CGM (black, before CL; blue, during CL), Ref (solid circles). Second: Insulin delivered. Third: Carbohydrates, intervention (red) and meals (blue). Bottom: Accelerometer orientation (black, >60 indicates sleep) and activity (blue, >10 indicates exercise).

Supplementary Table S1. Subject Demographics

Subject	*Age (years)*	*Sex*	*Race*	*T1D (years)*	*Daily insulin (U)*	*A1c (%)*	*Weight (kg)*	*U/kg/Day*
2101	29	F	White	8.9	56	8.7	59	0.94
2102	22	F	White	7.9	27	5.7	71	0.38
2103	31	M	White	15	43	8.5	77	0.56
2104	32	F	White	14	49	6.7	61	0.81
2105	31	F	White	14	66	6.9	63	1.05
2201	48	F	White	30	26	6.2	64	0.40
2202	26	F	White	8.5	38	5.8	62	0.62
2203	18	F	White	7.5	45	8.7	67	0.67
2204	42	M	White	4.8	42	6.4	99	0.42
2205	24	F	White	6.8	45	6.8	76	0.59
Mean/SD	30/9			11/7	44/12	7.0/1.2	70/12	0.65/0.23
3106	14	F	White	2	92	7.4	77	1.19
3107	30	F	White	15	45	6.2	69	0.65
3108	16	F	White	11	50	6.9	56	0.89
3109	14	F	White	13	57	8.8	50	1.14
3110	16	F	White	7.5	122	8.6	70	1.74
3201	48	F	White	30	26	6.2	64	0.40
3202	26	F	White	8.5	38	5.8	62	0.62
3203	18	F	White	7.5	45	8.7	67	0.67
3204	42	M	White	4.8	42	6.4	99	0.42
3205	24	F	White	6.8	45	6.8	76	0.59
3301	42	F	White	36	24	6.3	66	0.36
3302	27	M	White	25	46	6.2	84	0.55
3303	51	F	White	44	27	7.4	57	0.48
3304	44	F	White	34	31	5.8	68	0.45
3306	41	F	White	29	31	7.8	63	0.50
Mean/SD	30/13			18/13	48/26	7.0/1.1	68/12	0.71/0.38

T1D, type 1 diabetes.

Supplementary Table S2. Patient-Level 24-H Adjusted Results

Subject	*Mean (mg/dL)*	*CGM<50 (%)*	*50<CGM<70 (%)*	*70<CGM<180 (%)*	*180<CGM<250 (%)*	*250<CGM (%)*	*Daily insulin (U)*
2101	147	0	3.17	69.1	20.4	7.28	57.9
2102	117	0.17	1.26	92.7	5.86	0	20.6
2103	131	0	1.77	89.8	6.01	2.44	47.8
2104	126	0	2.81	91.0	6.17	0	53.5
2105	129	0	6.74	82.4	5.79	5.10	57.1
2201	161	0	1.01	70.9	17.3	10.8	26.8
2202	133	0	1.04	83.1	10.2	5.59	36.6
2203	151	0.17	1.57	70.2	19.7	8.35	50.8
2204	161	0	2.87	67.9	18.6	10.7	47.5
2205	169	0	0	59.3	38.9	1.82	67.1
Mean	142	0.03	2.22	77.6	14.9	5.20	46.6
3106	144	0	0.35	82.1	13.9	3.40	86.1
3107	151	0	0.87	66.5	31.5	0	47.0
3108	151	0	4.53	67.9	21.2	5.55	54.2
3109	160	0.17	1.45	68.3	17.9	11.2	60.9
3110	183	0	0.35	53.1	29.0	17.1	134
3201	158	0	0	76.5	16.0	7.15	30.1
3202	169	1.78	3.53	60.8	19.8	13.3	46.6
3203	159	0	1.39	68.2	16.9	13.0	63.5
3204	164	0	0	65.4	25.6	8.65	47.4
3205	146	0	0.58	79.6	15.8	3.65	44.1
3301	144	0	4.06	66.8	25.6	1.87	28.5
3302	133	0	2.25	84.6	11.9	0.87	37.9
3303	143	0	0	84.5	15.4	0	24.3
3304	139	0	0	82.6	13.1	3.70	28.3
3306	130	0	0.12	93.5	5.73	0	25.5
Mean	152	0.13	1.3	73.4	18.6	5.96	50.5

Supplementary Table S3. Inpatient 34-H Results and Hotel 51-H Results

Subject	*CGM<50 (%)*	*50<CGM<70 (%)*	*180<CGM<250 (%)*	*250<CGM (%)*	*Max (mg/dL)*	*Min (mg/dL)*
2101	0	2.34	22.6	9.10	319	62
2102	0.26	1.90	10.5	0	226	49
2103	0	1.30	8.61	3.11	319	60
2104	0	2.34	5.99	0	202	58
2105	0	5.54	8.69	7.75	311	54
2201	0	1.52	17.6	9.15	356	57
2202	0	0.75	14.8	8.07	338	68
2203	0.25	1.98	20.0	5.93	285	48
2204	0	2.09	22.0	8.15	312	61
2205	0	0	40.1	1.41	257	104
Mean	0.05	1.98	17.1	5.27	293	62
3106	0	0.32	14.8	3.10	281	62
3107	0	0.82	27.3	9.57	330	66
3108	0	4.45	21.5	4.62	329	63
3109	0.16	2.13	18.7	9.46	359	46
3110	0	0.33	28.9	17.0	352	66
3201	0	0	17.2	5.91	362	80
3202	2.26	3.29	19.8	13.9	401	39
3203	0	1.54	19.1	13.9	401	52
3204	0	0	24.0	9.15	303	71
3205	0	1.33	15.1	3.17	272	62
3301	0	3.77	26.3	2.45	275	51
3302	0	2.14	12.1	0.82	263	55
3303	0	0	12.0	0	245	79
3304	0	0	22.2	8.28	332	72
3306	0	0.17	5.49	0	229	69
Mean	0.16	1.35	19.0	6.75	401	39

Supplementary Table S4. Patient-Level Daytime Results (Before 11 PM and After 7 AM)

Subject	*Mean (mg/dL)*	*CGM<50 (%)*	*50<CGM<70 (%)*	*70<CGM<180 (%)*	*180<CGM<250 (%)*	*250<CGM (%)*
2101	167	0	3.61	54.6	30.8	11
2102	119	0.26	1.89	89.1	8.81	0
2103	138	0	0	87.2	9.09	3.69
2104	135	0	4.23	86.5	9.3	0
2105	146	0	5.32	77.9	8.9	7.84
2201	177	0	1.54	56.1	25.9	16.5
2202	145	0	1.56	74.7	15.4	8.39
2203	154	0.26	2.35	67.4	25.9	4.08
2204	156	0	4.31	63.6	20.1	11.9
2205	180	0	0	47.7	49.5	2.79
Mean	152	0.05	2.48	70.5	20.4	6.62
3106	149	0	0.52	81.5	12.7	5.1
3107	159	0	1.31	60.3	36.8	0
3108	150	0	6.8	59.1	25.5	7.28
3109	166	0.26	2.17	64.4	18.2	14.0
3110	177	0	0.52	54.8	29.3	14.7
3201	170	0	0	67.8	21.2	10.7
3202	171	2.67	5.3	53.8	23.3	14.0
3203	177	0	2.08	54.4	23.8	19.0
3204	169	0	0	62.3	24.6	13.0
3205	152	0	0.87	74.5	18.6	5.47
3301	153	0	4.79	56.5	34.7	2.81
3302	142	0	3.37	76.9	17.9	1.3
3303	146	0	0	83.5	16.4	0
3304	151	0	0	73.9	19.7	5.56
3306	134	0	0.17	90.2	8.6	0
Mean	158	0.2	1.86	67.6	22.1	7.52

Supplementary Table S5. Patient-Level Nighttime Results (11 PM–7 AM)

Subject	*Mean (mg/dL)*	*CGM<50 (%)*	*50<CGM<70 (%)*	*70<CGM<180 (%)*	*180<CGM<250 (%)*	*250<CGM (%)*
2101	107	0	2.29	97.7	0	0
2102	114	0	0	100	0	0
2103	117	0	5.21	94.8	0	0
2104	107	0	0	100	0	0
2105	97	0	9.38	90.6	0	0
2201	131	0	0	99.0	1.04	0
2202	110	0	0	100	0	0
2203	144	0	0	75.8	7.29	16.9
2204	172	0	0	76.3	15.6	8.12
2205	148	0	0	80.8	19.2	0
Mean	125	0	1.69	91.5	4.31	2.5
3106	135	0	0	83.2	16.3	0
3107	135	0	0	78.8	20.7	0
3108	152	0	0	85.4	12.5	2.08
3109	146	0	0	76.4	17.4	5.73
3110	195	0	0	49.6	28.5	21.9
3201	135	0	0	93.9	5.62	0
3202	163	0	0	74.9	12.6	12.0
3203	124	0	0	95.7	3.12	1.15
3204	155	0	0	71.8	27.7	0
3205	135	0	0	89.8	10.2	0
3301	127	0	2.6	87.5	7.29	0
3302	114	0	0	100	0	0
3303	139	0	0	86.5	13.5	0
3304	113	0	0	100	0	0
3306	122	0	0	100	0	0
Mean	139	0	0.17	84.9	11.7	2.86

Supplementary Table S6. Patient-Level 24-H Adjusted Baseline Open-Loop Results

Subject	*Mean (mg/dL)*	*CGM<50 (%)*	*50<CGM<70 (%)*	*70<CGM<180 (%)*	*180<CGM<250 (%)*	*250<CGM (%)*
3106	139	1.79	7.87	66.2	19.9	3.23
3107	136	0.86	3.74	76.6	15.3	3.01
3108	165	0	1.93	60.0	25.2	11.9
3109	179	0	0.95	52.2	32.6	13.6
3110	176	0.23	0.77	56.6	22.9	18.7
3201	138	0.45	7.84	64.2	22.5	3.81
3202	137	1.09	4.98	77.1	13.2	2.87
3203	217	1.53	4.59	29.8	24.0	38.8
3204	155	0.33	3.2	66.6	18.2	10.3
3205	160	0	5.07	59.2	22.2	12.9
3301	157	0.98	2.37	65.1	21.9	8.43
3302	143	0.31	4.38	72.8	18.0	3.75
3303	163	0	1.3	66.8	19.2	12.0
3304	152	0	4.64	64.9	22.6	7.08
3306	190	0	0.75	51.3	29.2	18.0
Mean	160	0.5	3.63	62.0	21.8	11.2