Case Study 4.2: **Low carb lunch**

23 / 24.07.24 V.1.0

This paper is about putting the **settings** I had (about 2 years ago) established **for my entire usual meal spectrum** to the test, with two extremely low-carb lunches.

Method

FCL (no carb inputs, no user boli) with dev variant of AAPS 3.2.0.4 w/autoISF 3.0.1:
Lyumjev 100 (DIA 7h) in Combo pump w/ 10mm Teflon cannula (0-48h)
2 x G6 overlapping (see case study 1.5; sensors used ~ d3 – d15; xDrip, no smoothing in AAPS)
TDD ~ 35 U; profile basal ~ 14 U (0.41…0.75 U/h); profile_ISF 36…44 mg/dl/U; iobTH% = 0.6
Key settings for entire meal spectrum (~ 20 … 90 g carb per meal):
SMB size limited at ~ 3.5 U (=2.9 x 120 minutes basal)
autoISFmax = 2.9; SMB delivery ratio = 0.75 fixed
bgAccel_ISF_weight = 0.22; break_weight 0.12; lower:ISF-range_weight 0.7; higher_ISF-range_weight 0.1; pp_ISF_weight = 0.03; dura_ISF_weight 0.8

Fish + veggie lunches managed by autoISF FCL

Settings that were better proven to work for fairly high carb meals (see e.g. Xmas case study 4.3) were put to the test with two (for “my spectrum”) extremely low carb meals.

Two very similar meals were set up for two consecutive days, with an option to lower, on the second day, the iobTH or any of the …_ISF_weights.

> As the FCL e-book suggests (in section), it would be easy to “nudge’’ my FCL for an “outlier” of comparatively low insulin need
>
> - by lowering iobTH% either directly, or indirectly (via low %profile, high TT + exercise button)
> - by elevating the effective ISF via lower bgAccel_ISF_weight and / or pp_ISF_weight, and/or via a lower % profile

The first example shown was a cod fillet plus broccoli with herbal crème cheese (12:10)

As that went well without any manual intervention…

other than, 2.5 -3 hours after the meal, 2 small cookies before/after a dogwalk

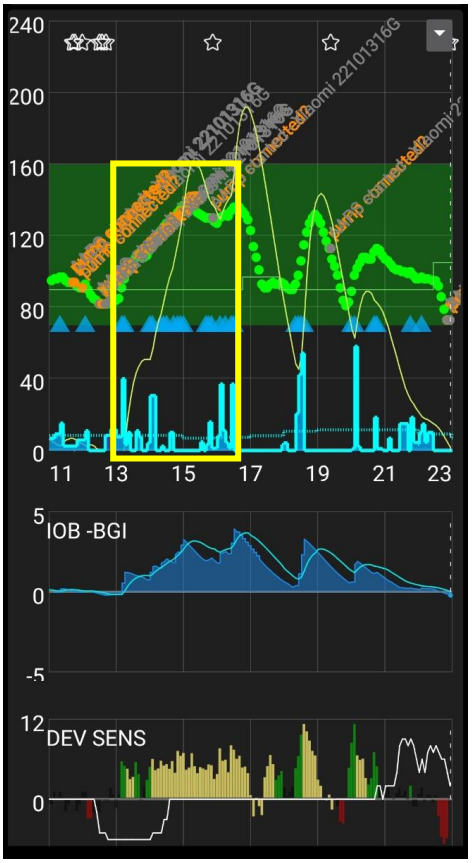
…no settings changes were made for the second meal, which had about same carbs and calories.

Note that iob stayed under 4U all the time, and under 2U in first 2 hours after meal start. That is well below my iobTH of 6 U.

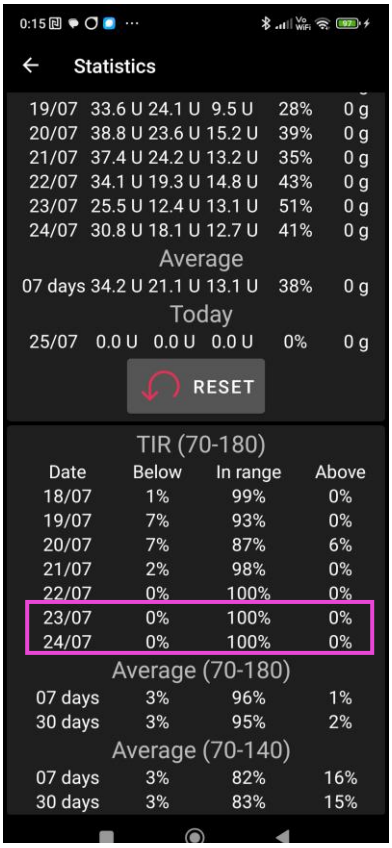
The 2nd meal was (on 24.July'24)

2 small tuna steaks, and black beans (12:50).

Now the initial iob rose stronger (probably because black beans have more carb than broccoli) but remained in the 3 U magnitude in first 2 hours after meal start



Despite aggressive settings that would quickly deliver big SMBs and exceed iobTH, we experience very moderate SMBs, and no hypo tendency at all.

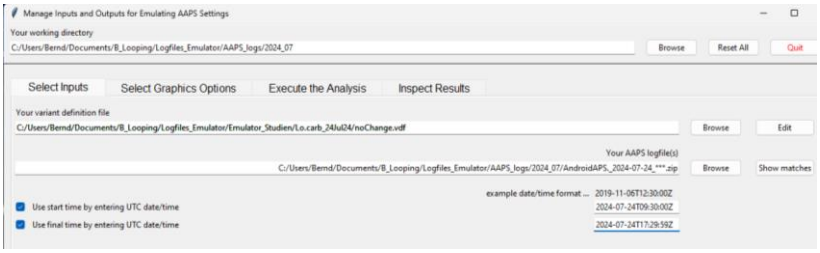


On both days, 100% TIR was achieved:

Analysis using the Emulator

Let us have a look how the autoISF factors contributed to provide appropriate iob (well below iobTH in this low carb case).

Following section 10.2.1 – 10.2.4 of the FCL e-book, analysis of the 2nd meal (24th July):



Execute analysis / run emulation / inspect results / csv =>

In column C: AAPS time = UTC time (B) + 2/24 ; format without seconds

Hide not important lines and columns =>

eat ->

	A	C	E	F	G	L	M	N	Q	R	S	V	W	X	Y	AA	AB	AC	AD	AE	AF	AH	AI	AK	AO	AQ	AR
1			bg	bg	targ		eff.	tol.	final	dura		parab	parab	parab	parab	acce	bg	pp	delta	dura	final			Ins.			SMBs
2		AAPS	accel	brake			iobTH	iobTH	ISF	min-	dura	fit	fit	fit	fit	ISF	ISF	ISF	ISF	ISF	ISF	ISF	ISF	Req.	SMB	TBR	dri-
3	id	time				iob	emul	emul	orig	utes	avg.	correl	durat	last-	next-	emul	emul	emul	emul	emul	emul	prof	emul	emul	emul	emul	ven
10	6	11:51	92	92	90	0,02	6	7,8	0,89	75	96,1	1	45	-1,3	-1,5	0,97	0,89	1	1	1	0,89	44	49,5	0	0	0,39	
11	7	11:56	91	91	90	0	6	7,8	0,87	80	95,8	1	25	-1,3	-1,6	0,97	0,87	1	1	1	0,87	44	50,3	0	0	0,385	
12	8	12:06	93		90	-0,03	4,92	6,4	0,74	90	95,6	0	0	0	0	1	0,9	1	1	1	0,74	43	58,1	0,14	0,1	0,731	
13	9	12:11	90		90	0,08	3,84	4,99	0,55	90	95,1	0	0	0	0	1	0,86	1	1	1	0,55	43	78,1	0	0	0	
14	10	12:16	87		90	0,03	3,84	4,99	0,54	5	88,5	0	0	0	0	1	0,84	1	1	1	0,54	43	80,1	0	0	0	
15	11	12:21	85		90	-0,02	3,84	4,99	0,53	10	87,3	0	0	0	0	1	0,82	1	1	1	0,53	43	81,4	0	0	0	
16	12	12:26	84	84	90	-0,07	4,92	6,4	0,67	10	85,3	0,9995	20	-1,2	-0,5	0,92	0,82	1	1	1	0,67	43	64,1	0	0	0	
		12:31	82	82	90	-0,11	6	7,8	0,8	15	84,5	0,9973	25	-1,2	-0,8	0,95	0,8	1	1	1	0,8	43	53,5	0	0	0	
		12:51	84		90	-0,19	6	7,8	0,87	35	83,5	0,9929	45	1,1	1,7	1,06	0,82	1	1	1	0,87	43	49,5	0,1	0	0,75	
		12:56	85		90	-0,17	6	7,8	0,87	40	83,7	0,9976	25	1,5	2	1,05	0,82	1	1	1	0,87	43	49,5	0,1	0	0,77	
20	16	13:01	84		90	-0,14	6	7,8	0,82	45	83,7	0,8103	45	1,4	1,7	1	0,82	1	1	1	0,82	41	50,1	0	0	0,47	
21	17	13:06	85	85	90	-0,14	6	7,8	0,83	50	83,8	0,9998	30	0,5	0,4	0,99	0,82	1	1	1	0,82	41	49,7	0,02	0	0,495	1,2
22	18	13:11	91		90	-0,14	6	7,8	1,15	0	91	0,9826	20	4	5,7	1,31	0,87	1	1	1	1,15	41	35,8	1,01	0,7	2,57	acce
23	19	13:16	96		90	0,74	6	7,8	1,3	0	96	1	25	5,7	7,4	1,38	0,94	1	1	1	1,3	41	31,6	0,79	0,5	0,22	
24	20	13:21	100		90	1,2	6	7,8	1,18	5	98	1	40	5	5,8	1,18	1	1,12	1	1	1,18	41	34,8	0,06	0	0,67	
25	21	13:26	102	102	90	1,19	6	7,8	0,9	10	99,3	0,9997	20	2,4	1,1	0,85	1	1,06	1	1,01	0,9	41	45,7	0	0	0	
26	22	13:31	104	104	90	1,12	6	7,8	0,92	10	102	0,9997	25	1,5	0,3	0,86	1	1,06	1	1,02	0,92	41	44,8	0	0	0	
27	23	13:36	108	108	90	1,03	6	7,8	1,08	15	104	0,9992	35	2,6	2,3	0,96	1	1,12	1	1,03	1,08	41	38	0,08	0	0,71	
28	24	13:41	110	110	90	1,01	6	7,8	1,02	15	106	1	40	2,3	2	0,96	1	1,06	1	1,04	1,02	41	40,2	0	0	0,51	
1 h ->		13:46	108	108	90	0,96	6,36	8,27	1,02	15	108	0,9876	40	0,5	-0,3	0,93	1	1	1	1,04	1,02	41	40,2	0	0	0	
		13:51	108	108	90	0,88	6,36	8,27	1,02	20	108	0,9986	45	-0,4	-1,2	0,91	1	1	1	1,05	1,02	41	40,3	0	0	0	
		13:56	109	109	90	0,77	6,36	8,27	1,06	25	108	0,9853	45	-0,6	-1,3	0,93	1	1,03	1	1,07	1,06	41	38,8	0	0	0,29	0,8
32	28	14:01	112		90	0,7	6,36	8,27	1,43	30	108	0,9999	20	2,9	4,4	1,35	1	1,09	1	1,08	1,43	40	28,1	0,71	0,5	2,003	acce
33	29	14:06	116		90	1,27	6,36	8,27	1,39	30	110	1	20	4,1	5,6	1,31	1,01	1,12	1	1,09	1,39	40	28,7	0,42	0,3	1,98	
34	30	14:11	118		90	1,64	6,36	8,27	1,14	10	115	0,9974	40	2,6	3	1,07	1,01	1,06	1	1,04	1,14	40	35,2	0	0	0,023	
35	31	14:16	120	120	90	1,53	6,36	8,27	1,05	10	118	1	20	1,9	1,4	0,93	1,01	1,06	1	1,04	1,05	40	38,2	-0,03	0	0	0,4
36	32	14:21	123		90	1,41	6,36	8,27	1,16	15	119	1	30	2,7	2,7	1	1,02	1,09	1	1,07	1,16	40	34,6	0,66	0,4	0,16	pp
37	33	14:26	125	125	90	1,71	6,36	8,27	1,13	20	120	0,9999	25	2,1	1,9	0,97	1,02	1,06	1	1,09	1,13	40	35,5	0,34	0,2	0	
38	34	14:31	127	127	90	1,78	6,36	8,27	1,14	20	123	1	30	2	1,8	0,98	1,02	1,06	1	1,1	1,14	40	35,2	0,48	0,3	0	
39	35	14:36	128	128	90	1,96	6,36	8,27	1,09	20	125	0,9999	20	1,1	0,6	0,93	1,02	1,03	1	1,1	1,09	40	36,7	0,03	0	0,643	
40	36	14:41	130	130	90	1,87	6,36	8,27	1,15	20	127	1	35	1,6	1,4	0,98	1,02	1,06	1	1,11	1,15	40	34,7	0,89	0,6	0	

2 h ->

	A	C	E	F	G	L	M	N	Q	R	S	V	W	X	Y	AA	AB	AC	AD	AE	AF	AH	AI	AK	AO	AQ	AR
		14:46	130	130	90	2,35	6,36	8,27	1,15	25	127	0,9981	30	0,7	0,3	0,95	1,02	1	1	1,14	1,15	40	34,8	0	0	0	
		14:51	133	133	90	2,21	6	7,8	1,15	30	128	0,9931	45	1,2	1	0,98	1,03	1,09	1	1,17	1,15	40	34,8	0,52	0,3	0	
		14:56	135		90	2,36	6	7,8	1,18	30	130	0,9999	20	2,3	2,8	1,09	1,03	1,06	1	1,18	1,18	40	34	0,91	0,6	0	
44	40	15:01	137		90	2,79	6	7,8	1,21	35	131	1	35	2,1	2,3	1,03	1,03	1,06	1	1,21	1,21	40	33	0,67	0,5	0	
45	41	15:06	136	136	90	3,12	6	7,8	1,09	35	132	0,9796	20	-0,1	-1,3	0,89	1,03	1	1	1,22	1,09	40	36,9	0	0	0	
46	42	15:11	135	135	90	2,94	6	7,8	1,08	40	132	1	25	-1,3	-2,4	0,86	1,03	1	1	1,25	1,08	40	37,1	0	0	0	
47	43	15:16	136	136	90	2,76	6	7,8	1,24	45	133	0,9991	45	0	-0,2	0,97	1,03	1,03	1	1,28	1,24	40	32,2	0	0	0	
48	44	15:26	133	133	90	2,39	6,36	8,27	1,35	55	133	0,9983	35	-1,5	-2	0,94	1,03	1	1	1,35	1,35	40	29,7	0	0	0	
49	45	15:30	132	132	90	2,21	6,36	8,27	1,43	60	133	0,9994	30	-1,3	-1,5	0,97	1,03	1	1	1,38	1,43	40	28	0	0	0,337	
50	46	15:36	131		90	2,05	6,36	8,27	1,5	65	133	0,9995	20	-1,1	-0,9	1,03	1,03	1	1	1,41	1,5	40	26,7	-0,04	0	0	
51	47	15:41	130		90	1,88	6,36	8,27	1,53	70	133	1	25	-0,9	-0,8	1,03	1,02	1	1	1,44	1,53	40	26,2	0,11	0	0,697	
3 h ->		15:46	130		90	1,82	6,36	8,27	1,56	75	132	0,9985	25	-0,3	0,1	1,08	1,02	1	1	1,47	1,56	40	25,7	0,27	0,2	1,017	
		15:51	130		90	1,94	6,36	8,27	1,59	80	132	1	30	0,1	0,4	1,08	1,02	1	1	1,5	1,59	40	25,2	0,28	0,2	0,08	
		16:01	127	127	90	1,83	6	7,8	1,5	90	132	1	25	-1,3	-1,6	0,97	1,02	1	1	1,56	1,5	39	26	-0,04	0	0,46	
55	51	16:06	130		90	1,71	6	7,8	1,59	95	132	0,8717	45	0,2	0,4	1	1,02	1,09	1	1,59	1,59	39	24,6	0,93	0,6	2,34	
56	52	16:11	131		90	2,45	6	7,8	1,62	100	132	0,9959	25	1,9	2,8	1,19	1,03	1,03	1	1,62	1,62	39	24,1	0,12	0	0,72	
57	53	16:16	132		90	2,35	6	7,8	1,65	105	132	1	40	1,4	1,8	1,09	1,03	1,03	1	1,65	1,65	39	23,7	0,34	0,2	0,29	
58	54	16:21	131	131	90	2,4	6	7,8	1,46	110	132	0,9949	20	-0,7	-1,9	0,87	1,03	1	1	1,68	1,46	39	26,7	0	0	0,1	
59	55	16:26	134		90	2,24	6	7,8	1,71	115	132	0,9998	40	1,7	2	1,07	1,03	1,09	1	1,71	1,71	39	22,8	1,14	0,8	2,76	4,9
60	56	16:31	136		90	3,07	6	7,8	1,74	120	132	1	45	2	2,4	1,07	1,03	1,06	1	1,74	1,74	39	22,4	1,29	0,9	0	dura
61	57	16:36	136	136	90	3,78	6	7,8	1,77	125	132	0,9971	35	1,1	1,1	1	1,03	1	1	1,78	1,77	39	22	0	0	0	
4 h ->		16:41	136	136	90	3,58	6	7,8	1,59	130	132	0,9896	20	-0,5	-1,7	0,88	1,03	1	1	1,81	1,59	39	24,5	-0,41	0	0	
		16:51	132	132	97	3,15	6,36	8,27	1,5	140	132	0,9996	20	-2,3	-3,1	0,9	1,02	1	1	1,68	1,5	39	25,9	0	0	0	
		16:56	129	129	97	2,93	6,36	8,27	1,53	145	132	1	25	-3	-3,9	0,9	1,01	1	1	1,7	1,53	39	25,5	0	0	0	
65	61	17:01	123	123	97	2,72	6,36	8,27	0,9	15	130	0,9984	20	-5	-6,3	0,85	1,01	1	1	1,07	0,9	38	42	0	0	0	
66	62	17:06	114	114	97	2,5	6,36	8,27	0,71	0	114	0,9998	20	-8,5	-11	0,71	1	1	1	1	0,71	38	53,6	0	0	0	
67	63	17:11	108	108	97	2,29	6,36	8,27	0,85	0	108	0,9997	45	-7,9	-9,2	0,85	1	1	1	1	0,85	38	44,7	0	0	0	
68	64	17:16	101		97	2,08	6,36	8,27	0,94	0	101	1	20	-6,9	-6,7	1,03	0,92	1	1	1	0,94	38	40,2	0	0	0	
69	65	17:21	93	93	97	1,89	6,36	8,27	0,83	0	93	0,9999	25	-7,3	-7,4	0,98	0,83	1	1	1	0,83	38	45,7	0	0	0	
70	66	17:26	91	91	97	1,69	6,36	8,27	0,82	5	92	0,9966	25	-4,6	-3,7	0,89	0,82	1	1	1	0,82	38	46,5	0	0	0	
71	67	17:31	91		97	1,52	6,36	8,27	0,96	10	91,7	0,9997	20	-0,1	2,7	1,17	0,82	1	1	1	0,96	38	39,7	0	0	0	13:00
92			82						0,53							0,71	0,8	1	1	1		36	22		0		to
93			137						1,77							1,57	1,03	1,27	1	1,81		44	81,4		1,1		16:30
94																									10,8	2,82	7,3

In 3.5 hours after eating, a total of 7.3 U were given as SMBs.

Despite a strong bgAccel_ISF _weight (0.22, *which can result in SMB sizes over 3 U at high carb meals*!), the insulination in the first hour remains moderate. Driven by bgAccel_ISF, only 2.0 U are given in 4 SMBs. BG (E) does not exceed 120 in this time while iob (L) remains under 1.7 U.

There is only a very brief phase, about 1 ½ hours after eating, where for just 10 minutes pp_ISF plays a role to deliver 0.4 U SMB (AO36)

As expected for a low carb major meal, between hour 2 and 4 there is a fairly constant trickle of more carbs being absorbed, while a stream of dura_ISF driven SMBs (A= 40 – AO59) provides a total of 4.9 U of dura_ISF driven SMBs.

This is in line of FCL e-book section 4 where the instructions for initial tuning were to use bgAccel_ISF for rapid initial SMBs suitable for all meals; then pp_ISF for elevating iob over iobTH in high carb meals; and for (s)low carb, we deal with late plateaus via dura_ISF. Interestingly, we do not see an effect of bgBrake_ISF, which was suspected for low carb also in section 4.4

Discussion of results

Optimization potential for low carb meals?

The investigated low carb meals were managed very well with the settings that also suit higher carb meals.

In case there were ideas for potential further improvements:

- the difference that modified settings *would make* could be analyzed using the Emulator with a "what-if" vdf. See FCL e-book section 10.3 for analysis on your PC, and (especially neat for AAPS:) the *real-time* emulator analysis of a *what-if* question, with speech synthesis on your smartphone, telling you for every loop decision how it would be impacted. See FCL e-book section 11.4
- it must be critically checked whether, after such optimization, *other* meals in your spectrum then might suffer. It is problematic, to fine tune just for one kind of meal.(See FCL e-book section 8, and case study 8.2),
- the user could also choose to create 2 or more differentiated sets of parameters, suited to different eating habits at lunch vs at dinner, for instance, and optimize both independently.

Was I just lucky – Could there be trickier cases?

We know that super big meals do not pose much extra difficulty, if the system was set up for a diet spectrum that included meals with max carb "burn rate" of around 30g/h (ref: Chapter 8 in: https://github.com/danamlewis/artificialpancreasbook/ -)

The presented case study showed that low carb meals are also easily managed.

Reduced-size meals (or high carb snacks) that trigger really aggressive first SMBs due to (a limited amount of) **fast resorbing carbs would be more problematic,** and might require a manual intervention. - See case study 5.2 re. sweet snacks.