1

Managing the late phase of a meal

Meal Management, section 3 –   V.0.0 (<mark>rough draft</mark>)

Now we are getting to the **late phase of a meal** which is where the **loops really take over the management**, and take care of the late carbs and fat/protein units (FPU). How they do this differs by the used algorithm, so we can only roughly sketch the common key points, and must give some references for further study.

We then touch on common troubles in the late phase, notably hard-to-correct high values, and how to deal with those and with other troubles.

We close this chapter with a critical view on some interventions into the loop, which may or may not be smart when we are dissatisfied with our loop.

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Carb entries for late phase

For the late phase, i.e. the time window when our meal bolus lost most of its power (Rule of thumb: 75-80% is lost about 3 hours after bolus for Humalog; or 2.5 hours for Fiasp; or 2 hrs with Lyumjev) we must enter the carbs that will be absorbed **after** this time window. Roughly, carbs exceeding ~ 60g (with slow insulins 75-90g) come to absorption now.

36 We just inform the loop of how much (gram amounts) and about when (absorption times) more
37 carbs will be absporbed and require insulin activity. We do not bolus for those, and – this may
38 depend on your looping system – you do not enter them into the calculator but via a special „eCarbs"
39 entry (e.g. Carbs button in AAPS).

40 The **„eCarb" amount** consists of:

41 • Carbs exceeding ~ 60g (with slow insulins 75-90g)

42 • plus a „FPU" contribution from proteins and fats, which can be counted as grams of e-Carbs
43   using factors 50-60**%** * g (protein); or 10-20**%** * g (fat).

44 • Also lower %age for protein and higher %age for fats is sometimes suggested *(see remarks in*
45   *comments at bottom)*

46 • *Alternatively there is a conversion via kcal from fat&protein (see next page)*

47 Notably iOS Loop systems also require details about **absorption times.** These are derived for the e-
48 Carbs by major food component, and considering:

49 Limited total absorption capacity (~ 30g/h)

50 Absorption is slowed by fibre

51 Absorption is slowed by fat .

52 3 pages later we will look into this in more detail.

53 Carb and e-Carb **entries** (amounts and absorption time info) can also be partially automated and
54 connected to food databases like Sugarmate. (As we will discuss in the last chapter, detailing the
55 eCarbs carefully is not necessary with oref(1) systems).

56

57

58

59 Fat Protein Units (FPU)

60 With the following table we like to show for a meal rich in protein, and another one richer in carbs,
61 how fat and protein can be counted into late carbs, and what reasonable entries would be in the
62 bolus calculator (first 2.5 hours covered by bolus with rapid insulin) and into eCarbs (late carbs
63 amount, absorbed in 3rd – 7th hour).

$$\# \text{FPU} = (\text{kcal from fat} + \text{protein}) / 100$$
$$\text{eCarb} \sim \#\text{FPU} * 5 \text{ g/FPU}$$

meal rich in proteien

component	g	% carb	carb	g carb in 1st 2,5 h	late carbs	kcal/g	kcal	FPU
Carb	34	100%	34	34	0	4,1	139	
Fat	33	10%	3,3	1	2	9,3	307	} 491
Protein	45	60%	27	4	23	4,1	185	4,9
Alcohol	20	0%				7,1	142	
total			64	39	25 *5		773	

Two main meals (example)

meal rich in carbs

component	g	% carb	carb	g carb in 1st 2,5 h	late carbs	kcal/g	kcal	FPU
Carb	60	100%	60	55	5	4,1	246	
Fat	30	10%	3	1	2	9,3	279	} 361
Protein	20	60%	12	2	10	4,1	82	3,6
Alcohol	20					7,1	142	
total			75	58	17 *5		749	

Late carbs from fats and proteins can be calculated:
a) via FPU, see yellow fields
   FPU*5 gives the grams eCarbs
   https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5686679 ;
   (up to *10 is used by some *Pediatr Diabetes. 2009;10(5):298–303. [PubMed]* , who deduct for „safety" afterwards)
b) via factors like 50-60% converting g Protein to g *mostly late* Carbs, and 10-20% for fat, see green darts.

High fat (or fibre) also slows absorption of originary carbs

No medical advice
see front page

64

65 The top right yellow box shows how FPUs (fat-protein-units) are calculated via the kcal/g from these
66 components. (To check for overall plausibility, you might occasionally add such a table up for an
67 entire day, and see whether it is plausible with your daily caloric needs).

68 The protein-rich meal delivered 491 kcal from protein and fat, which, divided by 100, is 4.9 FPU.

69 There is a controversy about which factor to use to convert these FPU into grams of eCarbs (red
70 arrows).

71 A (safer) factor of 5 is suggested e.g. by https:// www.ncbi.nlm.nih.gov/pmc/articles/PMC5686679 ;

72 up to *10 is used by others, e.g. *Pediatr Diabetes. 2009;10(5):298–303. [PubMed]*.

73 Alternatively, and faster to calculate in everyday life, the grams of protein and of fat can be
74 converted into eCarbs (green arrows) by using factors of 60%, or 10%, respectively.

75 The factor on fat may seem low. This may, at least in part, be owed to the secondary effect of fats to
76 stretch out the absorption of all carbs, which makes it seem that more late carbs originate from fats.
77 (More discussed in section ….).

78 -- Sources: --
79 Balancing Carbs, Protein, and Fat. Clinical review by Mary Hanson, registered dietitian. Kaiser Permanente. 03/01/2014
80 https://wa.kaiserpermanente.org

81 General overview, effects from proteins and fats: https://www.youtube.com/watch?v=4_5K9zH9CFc

82 FPE calculator via GooglePlay: EasyFPU. FPU calculators für iOS::
83 https://www.icloud.com/shortcuts/ac31808d809f40e1a9e63175f27152ac   ICLOUD.COM   Loop FPU   Robert's video
84 explaining his method: https://youtu.be/k8amkz9E66k   Loop FPU Food Entry (iOS Shortcut version)

85 Food databases: https://**sugarmate**.io   or   Fleisch - Tierische Produkte - Kalorien – **Fddb**

Insulin for the late phase

In the late phase of the meal, which can last several hours, the loop must provide insulin as required – but without the „tails" of the aggregated TBRs and microboli dipping the glucose level into the hypo zone later, when the flow of to-be-absorbed carbs has ceased.

Based on the insulin activity curves (p.10) the loop has always a pretty good picture how much insulin activity it has to work with in all upcoming 5 minute segments, and how to increase it via extra TBR>100%, or via Autobolus/SMB, or to decrease it via TBR<100%.

The challenge then is the carb absorption.

The carb absorption can either be inferred from the **glucose** movement in light of insulin activity. That is the basic approach of the oref(1) algorithm (more see section x.x in …. IC…pdf (link)).

Or absorption follow largely from inputs about **carbs eaten** and their absorption times *), which is the basic approach of iOS Loop. More see https://www.youtube.com/watch?v=4_5K9zH9CFc

Of course, in the end, both systems take into account all available information, and as user errors as well as a myriad of secondary influencing factors (see p.58) play into it, the so-called **deviations** play a big and similar role in both approaches . Deviations try to explain discrepancies the model sees, by saying, one of the parameters, e.g. carbs, must have been misjudged (in quantity or absorption time). Depending on which factor „gets the blame", **predictions** for the next 2 hours can look vastly different, but will converge as uncertainties decrease over time.

Predictions are the key part driving the loop's conservative behavior regarding **hypo** prevention, **from the „tail" of any insulin, that might be desirable to have on bord earlie**r.

How calculating the required and to-be-delivered (or withdrawn) insulin is exactly done, differs in many details between the open source loops, but it can be looked up **). Of note, in AndroidAPS much of it can be read (over like 5 full screens on the smartphone) in the SMB tab, every 5 minutes, if one desires to completely understand the loop's decison.

Loops differ also in how they can deal with fluctuations of user's **insulin resistance**. DIY have in-built (AAPS) or add-on options (IFTTT, Automate! for iOS Loop) to automate ISF and other parameter modulations. Loops may also include code that self-adjusts (Autosense, Autotune, Machine Learning/Artificial Intelligence), although with more or less hours of time-delay

-------------------------------- footnotes---

*) In one minute, Kenny explains why **absorption time** matters in iOS Loop:. https://youtu.be/UGtwnugWfKQ.

"Absorbing too fast, which is what you are seeing, generally leads to highs. If it doesn't, then your ISF is probably far too low and helps compensate for the incorrect settings.

When carbs absorb too quickly, the settings that could be impacted are:

1) basal too weak. Not enough insulin all around.

2) Carb ratio too weak (big). Most obvious from being high as well.

3) ISF too low/small. Sometimes leads to highs, but not if way too low." (Kenny F., L&L-FB, 16Jan'22)

) More on **algorithms: https://www.diabettech.com/looping-a-guide/comparing-the-loop-and-openaps-algorithms/ and (partially cited below): https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8087942/

126 **How each algo calculates InsulinRequired differs:**

127   (a) **AAPS** (and similar OpenAPS, Trio, iAPS):   reference/replace? with 1.2 of IC..pdf

128 The current heuristic algorithm of oref1 generates multiple future blood glucose predictions based
129 on (i) action of approximated insulin remaining in the body; (ii) the scenario in which all carbohydrate
130 intake ceases, and the system stops insulin delivery; (iii) action of approximated carbohydrates
131 remaining in the body; and (iv) unannounced meal absorption. The predictions are then combined to
132 estimate the lowest predicted glucose, and insulin delivery is adjusted to ensure that the local
133 minima remains within a pre-specified target. The user, similar to standard insulin pump therapy,
134 inputs their personal basal rate, insulin-to-carbohydrate ratio (IC), insulin sensitivity factor (ISF), and
135 curve of insulin pharmacodynamics. AAPS and the other oref loops also **enable automated insulin**
136 **coverage of meals without carbohydrate announcement via the "unannounced meal" (UAM)**
137 **feature**, whereby meals are anticipated based on available data suggesting an otherwise
138 unanticipated glycemic excursion. These unannounced meals may then be acted upon by a
139 supermicrobolus (SMB) wherein tiny boluses are delivered to more rapidly affect rising glucose
140 levels. Other features, not specific to unannounced meals, such as "**auto-sensitivity**" respond to
141 glucose fluctuations beyond the scope of predictions. These features used in combination enable
142 some users of AAPS or other oref loops to utilize their open-source system in a full closed loop mode.

143   The actual used data (every 5 minutes) can be looked up „live" in the AAPS SMB tab; or, for any 5 minute segment
144   in the past, in the AAPS logfiles; -> phone storage/emulated/0/Android/data/info.nightscout.androidaps/files.
145   There: „AAPS.log" contains the most recent data, and „AAPS_yyyy-mm-dd_(time in univ.time zone)_#.zip" are the
146   „historic" ones). Note this is not easy-to-read stuff. There are tools for analysis that load desired files from a time
147   window of interest to you. If you look in Github / ga-zelle / determine-basal-emulator: This even allows what-if
148   analysis on some changed settings you may like to investigate on paper … or even „live", with a voice telling you
149   every 5 minutes what would have been done differently! So, even that could be done, before jumping right into
150   trying it out.

151 **(b) iOS Loop**   See   https://www.youtube.com/watch?v=4_5K9zH9CFcv

152 The other open-source AID system, iOS Loop, uses a different algorithm that employs coincidence
153 point control (model predictive control),[16] and generates a single future prediction based on insulin
154 delivery history, **carbohydrates entered**, and other entered settings, including the basal rate, ICR, ISF,
155 and curve of insulin pharmacodynamics. When used in humans, users enter not only carbohydrate
156 counts but also an estimate of the **absorption time** of that particular meal or food. Loop uses two
157 forms of short-term adaptation called "glucose momentum" and "retrospective correction" to enact
158 temporary basal rates to push the projected glucose toward a specified target range. Glucose
159 momentum uses the 5-min rates of change from the prior 20 min to influence future predictions,
160 with most weight given to the most recent rate of change. In retrospective correction, glucose
161 differing from the predicted value causes that difference to be added to the next prediction. An
162 extension of this feature called "integral retrospective correction" takes not only the difference but
163 also the accumulated differences into account for more rapid adaptation.

164

165   • *Loops also differ in how they can **deal with fluctuations of user's insulin resistance**. (is*
166   *already touched on in preceding section .. try to unite, and add ActivityMonitor)   DIY have in-*
167   *built (AAPS) or add-on options (IFTTT, Automate! for iOS Loop) to automate ISF and other*
168   *parameter modulations. Loops may also include code that self-adjusts (Autosens, Autotune,*
169   *dynamicISF, autoISF, Machine Learning/Artificial Intelligence), although with more or less*
170   *hours of time-delay.*

171

Why is it often difficult to resolve a high post-meal glucose – and why, then, the sudden declines toward a hypo?

A post-prandial glucose rise can lead to insulin resistance (elevated insulin need). This often happens after fatty meals, and mechanisms behind it seem to be the following:

Stage 1: Free fatty acids (FFA) can block insulin receptors . More insulin is needed „to shovel them free" (A post-dinner walk can be very helpful, too).

Stage 2: Lipolysis: Insulin deficiency leads to cleavage of body fats into FFA and other components in order to obtain energy. When insulin deficiency is resolved, also the FFA must be removed (see stage 1)

In the moment when FFA were successfully removed using insulin, insulin sensitivity returns to normal.   Any insulin becoming active now (be it from a „rage bolus", or also what remains active from the last micro boli) can rapidly bring down glucose, sometimes ending in a hypo.

AAPS offers the option to customize the loop control by the user defining an „Automation": If a certain „pattern" was recognized, the loop can be told to react, when seeing such pattern, in certain ways: refer to AAPS readthedocs/FCL   Example: If in (def. time window after a meal) a (def. duration, slope) incline happens, change to other factors (e.g. higher-.% profile „override") for (duration, or until glucose smaller than …).

In all open-source loops, similar things can be automated with 3rd party add-on apps, like IFTTT or Automate!

------------------------ references --

Source about FFA (in German): Loopercommunity.org/ LongboatAline / Dr. Teupe. Mehr zu FFS: s. S.19-25 in: geb.uni-giessen.de › volltexte › pdf   O. Wüsten, Beeinflussung der Insulinresistenz durch freie Fettsäuren

Zu Profilwechsel bei Resistenz siehe auch die gute Diskussion in: https://de.loopercommunity.org/t/profilwechsel-bei-resistenz/2969

Automation: see (in English) Automation, use it wisely | Diawatch

199   **Nautical equivalent to temp. insulin resistance**

200

201   The situation with temporary insulin resistance because of blocked insulin receptors that we just
202   discussed, is paralleled in nautical terms as shown here:

203

204   We had used the nautical parallel before, to understand the implications from the sluggish and
205   delayed nature of control. Even just the momentum from pausing after the last executed paddle
206   stroke on the right, could make our boat, as symbolized with the blue ellipse in the picture, turn
207   away from the blue target line.

208   To get back on course, we would have to paddle strongly on the left (=to the right) (~give SMBs or
209   Autoboli); still, this would keep us drifting over the yellow border (~ „Fiasp works like water at high
210   values"…). Why?

211   The equivalent of the receptor blockages is here, that we need to somehow move about one ton of
212   water from the front right side of our boat to the other side, in order to face towards our goal line
213   again with our boat. (Calculation see sketch and blue insert)

214   Only when heavy paddling has achieved this, it is all of a sudden easier again (~ sudden return to
215   normal insulin sensitivity) to stir our course.

216   It is a typical beginner mistake to keep „correcting" until success is obvious,. But that is too much,
217   and the boat will head into the red zone next. (~ glucose roller coasters triggered when neglecting
218   the delayed control implications – as the loop algorithm uses in ist predictions).

219

220

221 **Trouble shooting for the late meal phase**

222

223 If you frequently face troubles in the late phase of a meal, one logical approach would be to first
224 solve major problems that might carry over from the early meal phase, so you do not start with a
225 super high glucose value into the late phase (and also not with a burden of too high iob, in a meal
226 situation with not many eCarbs to deal with).

227 Generally it is a good strategy to develop a stable loop with meals that do not push the limits. So,
228 limiting the amounts of components with very high glucose impact (see chart p.xxx) should help to
229 dial in all parameters right.

230 This table gives some basic ideas what might be wrong if certain problems are encountered.

The **late meal phase** can last for 6 and more hours; an incorrect basal rate or DIA could become noticeable, besides „the usual suspects". Problems might influence the next-following meal, and can be clearest seen in the night after dinner. The following table can only give rough guidance because the looping algorithms differ.

category	problem	likely cause	action, immediate	...for next day
glucose increases	in the beginning of the late phase	not enough active insulin (zero-temping in early phase)	„ride it out"; evtl.small bolus/Afrezza	front-load eCarbs enable bigger SMB/AB
	prolonged in the middle of the late phase	temp. resistance from fatty acids	set override /high%profile; Afrezza?	Automate a high override / %profile for a couple of AB/SMB
	stays high	ISF too weak absorption times too short too low eCarb input	evtl.small bolus/Afrezza; add carbs	lower the ISF increase absorption times input more late eCarbs
glucose dips low	towards the end of the late phase	DIA too short basal too high too much carbs entered user bolussed extra	take glucose & elevate TT	elevate DIA reduce basal improve carb input
„roller coaster"	repeatedly bouncing low	ISF too strong	take glucose & elevate TT	elevate the ISF reduce SMB/AB size limit

231

232 For super big meals with lots of fat and protein, problems might surface again, or get worse. Then
233 your choice would be to accept that and „ride it out". Or to prepare some of the immediate or even
234 „next day" actions from the table. My (author B.) favorite one is to provide my loop an automated
235 response to high glucose values *) , something like „if glucose >170, switch for 12 minutes to 20%
236 lower ISF".

237 Consult also „Loop tips - stuck on high": https://loopkit.github.io/looptips/how-to/high-bg/

238 Trouble very often is coming also from user interferences, notably from rage bolussing when the
239 glucose seems to stay too high for too long. We were not sure whether even to include small (!!)
240 extra boli (using the pump, or Afrezza) in the immediate remedies column. Try to manage without it,
241 your loop should have a better idea on where things are heading, notably for hypo prevention an
242 hour or more down the road.

243 --remark--*)
244 Generally though, try to avoid „home constructing" a loop within the loop! The justification here is, that we do know of
245 short-term elevated insulin resistance after fatty meals, as just discussed on the preceding 2 pages, and a short-term (e.g.
246 12 minutes = 2 ABs or SMBs) strengthening of ISF, only when values became high after a meal, can therefore be justified
247 (and has nothing to do with a sloppily set-up loop being patched over with new tricks). Actually this flexibilization is being
248 developed as a user tune-able new feature within the AAPS algorithm for 2022 („autoISF"); but users of current iOS or
249 oref(1) master looping software can meanwhile coarsly „home construct" it via an Automation add-on.

250 **Co-managing the loop in the late phase**

251

252 While the user took center stage with her/his bolus in the early meal phase, now, in the late phase,
253 the loop is supposed to manage the remaining meal time. However, we are often tempted to „help"
254 the loop.

255 The traffic light symbol on the left of the table symbolizes what we can (or maybe better, should not)
256 do in a desired co-manager role.

	Interference	Example	Note
⚪	setting temp. targets (early phase)	EatingSoonTT	even if not reached: insulin given by the loop considers the TT
🟢	setting temp. targets	ActivityTT for sports after the meal	Difficult because the loop front-loads insulin and zero-temps a lot in the late meal phase to hit normal target. A sportsTT would need to be set very early, leading to a weaker overall meal management. A good alternative would be a normal managed reduced meal size, then a sports snack with a late set ActivityTT
🟢	setting over-rides/%profile	(Automation with) elevated %profile for insulin resistance from FPUs	(see page 33)
🟢	Afrezza	for stopping glucose rise	(see next page)
🟠	changing key loop parameters depending on glucose level	glucose ⇔ ISF modulation (e.g. via an Automation)	tuning the ISF correctly agrees better with the algorithm
🔴	extra bolus (with info entered)	for correcting high glucose	= core job of the loop; not helpful to get the loop work right; loop will counter-regulate; still, likely ending in a hypo.

257

258 Starting from the bottom: What we really should avoid, is to give an extra „rage" bolus when values
259 go high and we are dissatisfied with our loop. Correcting high glucose is really the core job of the
260 loop. Your job is to **enable** the loop do a better job next day. So better watch, analyze what you see,
261 and adjust parameters for the next days. Your intervention would highly likely result in a
262 hypoglycemia a bit later.

263 A somewhat milder interference would be when the user modulates „aggressiveness" of the loop
264 based on the reached glucose level; this could also be automated. However, this would go against
265 the logic of the loop, which should really work with appropriate settings, notably ISF, without any
266 additional patching-up by the user.

267 To stop a glucose rise with the inhaleable insulin Afrezza is a possible but somewhat ambivalent
268 choice, as will be discussed on the following page.

269 Setting stronger ISF when temporary insulin resistance from fat happens, is a good co-managing
270 strategy that was already discussed ref.?.

271 Setting temporary targets is a benign way to „nudge" the loop in a desired direction. We had
272 discussed this already in context of EatingSoonTT in the pre-phase. Now, in the late phase, setting a
273 high ActivityTT might be helpful, not so much for meal management, but in case activity follows that
274 requires room for sinking glucose values. Actually, this can be quite a challenge for people who do
275 have meal management under good control: The loop front-loads insulin and zero-temps a lot in the

276 late meal phase, to hit the <u>normal</u> glucose target. An ActivityTT would need to be set very early, but
277 lead to a weaker overall meal management. A good alternative would be a normal managed <u>reduced</u>
278 meal size, then a sports <u>snack</u> accompanied by a late set ActivityTT.

279

280 **Afrezza to the rescue!**

281

282 **Afrezza** is an inhaleable very fast (and also short) acting insulin which could be useful **to correct high**
283 **glucose levels**.

284 In our nautical analogy: The tip of our boat has drifted to the left (blue ellipse). We move it back to
285 the right when „my girlfriend Afrezza" does a CANNONBALL JUMP next to the front left side of our
286 boat. The resulting **>>>**-wave orients our boat back towards target

287

288 **Pro:** Afrezza addresses a temporary extra need, and even without the hours-long tail of effects.

289 **Con:** Afrezza spray is hard to dose. Also it is not adviseable to enter data into loop because the
290 kinetics of this insulin are very different. Available data (see charts on next page) suggest that Afrezza
291 solves a problem in the first 60 minutes of application. However, things get worse thereafter, as
292 both, previous loop insulin AND Afrezza fade out quickly just as (around minute 90 …120 after a
293 meal) there is still strong carb absorption requiring active (!) insulin:

Figure. Glycemic Trends following Breakfast and Lunch

Observations/Questions Bernie:

90 minutes **after** meal starts, bg curve is WORSE with Afrezza: *Is this because a pre-bolus with more of a activity at around 60..120 minutes is fully replaced by a faster waning spray shot? Can the blue resp. green curves, made come down in minutes 90….210 * via more aggressve ISF and SMBs acting on the bg rise?*

* via a second Afrezza shot?

* via complementing the 1ˢᵗ Afrezza shot with a (reduced) pre-bolus?

Why is breakfast so well managed by HCL, and much more worse with Afrezza after 60 or after 90 minutes (also when we compare to the differences seen at lunch)? *Probably we must see the insulin activity curves (Afrezza not available in AAPS, though), + estimate the carb absorption characteristics for both meals …*

Upside: *FCL w/autoISF should be able to manage the 60 … 150 minutes situation*

Source: A. Galderisi et al, Abstract ID 290. ATTD Madrid 2020

294

295 In the 60 minutes after Afrezza application the loop saw bg movements but by far did not have all
296 related iob info (Afrezza contributions missing for the calculations). It is a problem when up to about
297 minute 60 after Afrezza application the loop sees good bg control at supposedly low active insulin;
298 But immediately afterwards (Afrezza effects then faded away quickly), data look like suddenly super
299 high insulin sensitivity - for which the loop can not suddenly provide active insulin. Hence the
300 glucose rises in minutes 90…120.
301 The situation will also result in false Autosens (if in use), with negative consequences in the upcoming
302 hours from skewed calculations .

303 **Still, Afrezza can be a reasonable remedy** in times. **Solving the problem at hand** as best as we can,
304 **even if it makes the time afterwards a bit more complicated, is the name of the game**. **We and our**
305 **loop do this all the time** (for instance, by giving more upfront insulin, then reducing basal (zero-
306 temping)).

307 A second shot when bg rises again could actually help, too.

308 But preferably, seek strategies that make you **stay better in range, and** avoid crazy extra moves with
309 Afrezza. (Experienced navigators can do without cannonball jumps by their crew!)

310

311

312 **Temptation to cheat the loop via „fake" data entry**

313

314 Generally, we want our loop to work smoothly, and have the best information we can give it.

315 To try to provoke a certain behaviour of the system via „nudging" it with fake inputs can certainly
316 work for some intended effect; however it is likely to create an imbalance and develop, at least
317 within the time frame of carb absorption from the given meal, and DIA of the insulin on bord, errors
318 and suboptimal further regulation capability of the loop. The most prevalent cases probably are:

319   •   the user rage bolus from a pen, without announcing it to the loop

320   •   the un-announced anti-hypo snack.

Trying to provoke a certain behaviour of the system via „nudging" it with fake inputs can certainly work for some intended effects. BUT: Generally, we want our loop to work smoothly, and have the best information we can give it.

	Interference	Example	Better strategy
🟢	un-announced Afrezza	input would be difficult because of totally different kinetic characteristics	optimizing early phase tuning the loop anti-FPU automation (p.33)
🔴	un-announced extra bolus (user)	e.g. to fight high glucose	patience; tune the loop
🟠	un-announced extra carbs consumed	e.g. to avert hypoglycemia	enter carbs, set high TT
🟠	under-reporting carbs		tune the loop
🔴	over-reporting carbs		tune the loop
🟠	basal rate or factors unrealistic		tune the loop
🔴	erasing past boli to lower iob and trigger more insulin by the loop	to fight high glucose (alternative to unanounced bolus)	tune the loop

321

322

323 **Special challenge: Meal followed by exercise**

324

325 Generally for exercise you will benefit from getting less insulin, and from having an elevated glucose
326 level - with „room" for it to go down

327   Exception: In very stressful (or super exciting) situations, glucose may be rising temporarily and might even briefly
328   require extra insulin

329

330   The blue box describes a standard situation with reduced insulin need…

331

For activity, we set HIGHER targets, and we are overriding standard settings with LOWERED profiles% (lowering basal, elevating IC and ISF).

This is **the OPPOSITE of what we need at/for meals** => It is a special challenge if activity follows a meal.

1. Activity in early meal phase

Reduce the meal bolus size

Set elevated glucose target

2. Activity in late meal phase

Set elevated target + longer absorption time

Need extra carbs

Activity can help resolve stubborn high glucose.

Example Person with IC=10 g/U and ISF = 40 mg/dl/U does activity that requires 20g carbs to prevent (or treat) hypo.

She/he should take less insulin for the meal, namely minus 20g/IC = minus 2 U. If meal bolus is 8 U this means 25% reduction. And/or a precautionary elevated glucose target could be set: Using the ISF, the 2 units „buffer" would be gained by adding 80 mg/dl to the hypo border, so setting ~ 160 mg/dl would make sense. (Note: To actually REACH it, the loop needs time or (and?) a snack! And no excess iob that drives glucose down)

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333   So, **for exercise**, we set a HIGHER target, and we are overriding standard settings with LOWERED
334   profiles% (lowering or completely shutting off basal; elevating IC and ISF) so a desired %age of
335   reduced insulin supply results..

336   This is **the OPPOSITE of what we need at/for meals** => It is a special challenge if exercise follows a
337   meal.

338   **1. Activity in early meal phase**

339   Make **partial bolus** and set **higher glucose target**

340   Deduct as much insulin from the normally given bolus, as is needed less due to activity. For instance,
341   if activiry would require 20g extra carbs to prevent hypo, use your IC to calculate the units of insulin
342   to reduce, in order to prevent the hypo without taking extra carbs: At IC = 10 g/U, 2 units of insulin
343   less should be given. So for instance 5 U insted of 7 U. Likewise, if your ISF is 40 mg/dl / U, you may
344   want to be about 80 mg/dl above hypo warning and should set a target around 160 mg/dl during
345   activity.

346   So you need to collect knowledge, for each of your typical activities, how much glucose you (!!)
347   typically need extra. Then use your (!) factors to estimate needed modification of inulin for meal, and
348   for set glucose target.

349   If it is unclear in the beginning how strenuous the activity will be, your options are to reduce bolus
350   for the meal even stronger, or to risk going low and requiring sports snacks (or sweet drink etc) later.

351   **2. Activity in late meal phase**

352   If activity starts when your loop is mostly zero-temping after having delivered the insulin as likely
353   needed for (most of) the meal, this is unfortunate. You have a risk of going low as is, and the loop
354   cannot do anything for you now. Before starting activity, be sure you do (or can) cover your needed
355   extra energy, for instance the 20g in the example used above.

356 On a positive note, a bit of activity (like the post-dinner walk) can actually be good to control glucose
357 in case you tend to go high for hours after meals, for instance, to resolve fat-induced high glucose
358 values due to increased resistance as sometimes seen 3-4 hours after a fatty meal (as discussed
359 p.34).

360 Depending on the amount of caution applied to prevent hypo during activity, a correction bolus may
361 be required when activity comes to an end.

362 If the activity is not too strenuous, you still may require insulin for late carbs. In that case, use an
363 override (a reduction of %profile), so the loop gives TBRs or microboli at a reduced rate, when
364 glucose gets above a certain BG #. In iOS loop, you can also play with extending the absorption time
365 of carbs.

366   Overall, it's a personal experiment to find what works good enough for you. Regarding exercise, it
367 very much depends on kind, duration, starting time relative to the meal.

368   Could mention here: ActivityMonitor for light activity/in-activity modulation of sens

369 ---more info---

370 There are extra resources (videos, blogs, FB posts) on sports management when looping Add ref. . Certainly the open
371 source systems offer much more adjustability to all kinds of also extreme sports. And there are other groups discussing
372 specifically kids, with their sometimes unpredictable eating and hopping-around habits.

373 Add references to "ultimate" examples:

374 • exercise mode x autoISF x FCL   How even a full closed loop can be prepared to automatically deal with this
375 challenge, can be seen in (FCL e-book Case study 6.2)
376 • Dana Lewis ultra-marathon
377

378 Link to Activity Monitor description (better integrate at beginning when talking about calibrating for normal situations ..
379 Modulating (manual, auto) for temp sens/resist.

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