Bolus Calculator review

Gillian Purcell, Bath and Maria Leveridge, Exeter
The Expert meter algorithm was never validated in paediatrics (source: company rep via Chair of DSGP, Sarah Almond Bushell)
Apps were downloaded and tested on android Samsung J3

Summary

Name of bolus calculator	Age 0-18	Bluetooth to meter	Android (A) iPhone (iP)	DIASEND capability	Cost	Acting time	Timeblock Number:	IOB	Exercise function	Illness setting	↑↓ for CGM arrow
MyLife	14+	√	A & iP	√	Free	2-8hrs	Up to 8	√	X	X	X
My Sugr	X	√	A & iP	X	Cost beyond basic	2-8hrs	hourly	√	X	X	X
Diabetes M	Only supervised by an adults	√	A & iP	Only with fee	Cost beyond basic	Not editable Assume based on insulin type	hourly	√	√*	√*	√*
Dario Smart meter app	No age limit on any documentation	√	A & iP	X	Free	3.5-5hrs	4	√	X	X	X
Hedia HDA	X	X	A & iP	X	Free	Not editable based on insulin type	1	√	√	X	X
RapidCalc			iP		£7.99						

*payment for additional functionality

Test

Settings Target (where possible to edit) 5.5/5.6mmol; ICR 1 unit to 10g; ISF 1 unit to 2mmol (Expert snack size set at 0g). Active insulin 3 hours (except Dario 3.5 hours). Expert meter define BG levels using Glucose control 2 LOT 23500116 Exp 2017/5. All other BG entries manual into bolus apps

Time 1: BG 14.7mmol and Carbs 40g (no exercise, no insulin on board)   **Time 2:** 2 hours after 1st dose, BG level 14.7mmol, 0g carb

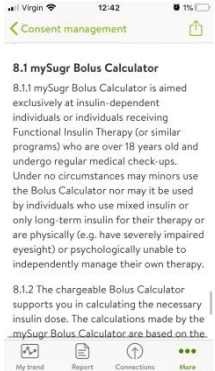| Name of bolus calculator	Time 1 Insulin dose recommendation	Time 2 Insulin dose recommendation	Time 2 Active insulin
Expert meter	8.5units (09.34hrs)	1.5 units(11.33hrs)	-2.4 units active insulin
MyLife	8.6 units (09.43hrs)	1.7 units (11.44hrs)	-2.9 units active insulin
My Sugr	8.5 units (09.44hrs)	3.5 units (11.44hrs)	no recommendation of less for active insulin
Diabetes M	*9 units (09.46hrs)	3 units (11.47hrs)	2.07 units active insulin noted but dose not adjusted by this
Dario Smart meter app	8.6 units (09.14hrs)	0.9 units (11.28hrs)	-3.7 units bolus on board
Hedia	8 units (09.50hrs)	2 units (11.55hrs)	-2.4 unit active insulin

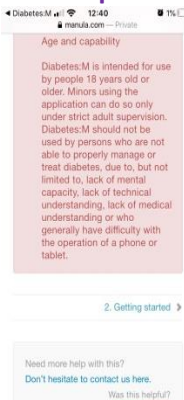*Advised delay eating for 10-20 minutes as out of target

Appendix: Information correct as of 4/5/20

The user settings on each app may not define the algorithm used to calculate IOB (I found Diabetes M & MyLife did)
Each app is free to download. The User Settings are available on each app. Before setting any patients up it is useful to familiarise yourself with the set up and the features. Below is a summary only. This information is likely to change as management systems are updated by the companies. Always refer to the app manual and update regularly.

RapidCalc https://www.glucomen.co.uk/rapidcalc/ not analysed as fee to download £7.99 and only available on iPhone

Name (manufacturer)	Age group –source of info	Meter that can directly blue tooth to calculator?	IOB	Cost	Connectivity to DIASEND	Negatives
My Life Ypsomed	Adults and children – Source: email from rep **Suitable for Children** **however on user guide:** *'Minors from age 14 should discuss use with their legal representatives as well as attending physician. Same applies to supervised persons.'*	**mylife Unio - Er** • Automatic data transfer • Connectivity to the My life App for bolus advice • Side-loading test strip • Automatic load and release function of mylife AutoLance	**Yes** **2 options**	**Free** **Android and Apple devices**	**Connects to Diasend** - BG on Diasend - Settings can be sent via pdf (email) - or can share sharing by to MYLIFE cloud optional Gives statistics of averages, standard day etc *10 user profiles can be set (would need to ensure select correct one). Probably not wise if more than one child with type 1*	No exercise function No illness function No % increases for CGM arrows The advice is in 0.1 units increments so individuals will need to round to nearest 0.5 (some families struggle to do this)

Time blocks: Can set different BG targets/ICR/ISF in 8 time blocks.

Insulin precision: 0.1 units

Active insulin: can set *duration of insulin action* manually from 2 hours – 8 hours

Dose adjustment: select one of two approaches on how IOB is calculated
   a) IOB subtracted from correction bolus and meal bolus
   b) IOB subtracted from correction bolus

Other features: Video (German): Child using the unio meter https://e.video-cdn.net/video?video-id=BkHz9BL4ci3cULca7NqV2Z&player-id=BznpC2jv3NMr59Ej-fnFkB
Maximum bolus can be set 0.5-30 units. Preset is 10 units. Manually entered BG in italics

Name (manufacturer)	Age group –source of info	Meter that can directly blue tooth to calculator?	IOB	Cost	Connectivity to DIASEND	Negatives
My Sugr	18 & over in Bolus calc manual 16 and over Logbook manual! *'under no circumstances can minors use the bolus calculator'* 8.1 mySugr Bolus Calculator 8.1.1 mySugr Bolus Calculator is aimed exclusively at insulin-dependent individuals or individuals receiving Functional Insulin Therapy (or similar programs) who are over 18 years old and undergo regular medical check-ups. Under no circumstances may minors use the Bolus Calculator nor may it be used by individuals who use mixed insulin or only long-term insulin for their therapy or are physically (e.g. have severely impaired eyesight) or psychologically unable to independently manage their own therapy. 8.1.2 The chargeable Bolus Calculator supports you in calculating the necessary insulin dose. The calculations made by the mySugr Bolus Calculator are based on the	Yes Accu Check Mobile Meter & Fastclix CGM data can be imported from Apple Health (iOS only). 3 hourly delay for Dexcom users	Yes	Free for basic version Upgrade to MySugr Pro **Android and Apple devices**	Report formats .csv (.pdf/Excel on MySugr Pro) can be emailed. No direct upload to DIASEND but Mobile Meter can be separately	It cannot calculate bolus advice if a) in state of hypo b) BG over 27.7 c) Log entry is 15 minutes after BG entered/taken

Time blocks: Can set different BG targets, ICR & ISF per hourly timeblocks

Active insulin: can set *active duration* of insulin manually from 2 hours – 8 hours

Dose adjustment: For the calculation: in addition to the set-up parameters that you provide, the algorithm uses current BG values, ingested carbs & current IOB which is calculated based on the insulin action curves of the respective insulin type.

Insulin precision: 0.1, 0.5, 1.0 and 2.0 units

Other features: BG reminders

Name (manufacturer)	Age group –source of info	Meter that can directly blue tooth to calculator?	IOB	Cost	Connectivity to DIASEND	Negatives
Diabetes M Sirma Medical Systems www.diabetes-m.com User guide the most detailed and thorough	18 or above **Minors using the app can do so only under strict adult supervision** [screenshot: Diabetes M app — Age and capability. Diabetes:M is intended for use by people 18 years old or older. Minors using the application can do so only under strict adult supervision. Diabetes:M should not be used by persons who are not able to properly manage or treat diabetes, due to, but not limited to, lack of mental capacity, lack of technical understanding, lack of medical understanding or who generally have difficulty with the operation of a phone or tablet.]	• CONTOUR NEXT ONE • ACCU-CHEK AVIVA CONNECT • ONETOUCH VERIO FLEX • And other devices that support Bluetooth smart glucose profiles • Can work with Freestyle Libre (ANDROID ONLY) –automatically connects –in paid version Contour® Next One Accu-Chek® Aviva Connect Accu-Chek® Guide Accu-Chek® Instant OneTouch Verio Flex® CareSens™ N Premier CareSens™ Dual One Drop™ Nipro 4SURE™ Smart Nipro 4SURE™ Smart Duo Nipro TRUE METRIX™ AIR Publix TRUE METRIX® AIR ReliOn™ • Links to Nightscout • FitBit will send data to Diabetes M (soon) Link to DropBox or Google drive	Yes	Free for basic version Have to pay monthly to get information you can share with team Paid for most of it e.g automatically putting readings into meter Android and Apple devices	HTML report s for free to HCP provider. Pdf/XLS report can be shared via email for review on paid account Information may not be stored if using free version To get full functionality have to pay per month	Have to enter in a weight/height before setting up. Wt is used for determining ISF & ICR default settings. Bolus advisor notifies when you need to delay a meal due to high blood sugar Worryingly it tracks calories with carbohydrates, gives advice on daily kcal needs, BMI outside normal limits (all will be adult biased)

Timeblocks: Set ISF/ICR in hourly increments. Can configure targets: Glucose Hi; Hyperglycaemia; BG target, Glucose low; and hypoglycaemia but no bespoke settings for different times BG target used to calc doses the others for warning alarms.

I**nsulin precision:** 0.5, 1.0 and 2.0 units

Active insulin: Active insulin time for IOB can be set for 2 - 8 hours

Dose adjustment:
IOB based on IOB carb and IOB correction
Advice can be adjusted based on arrows for Libre and Dexcom
Extended bolus calculation based on ↑ fat/protein foods but user selects % split, based on Pankowska for extended bolus (WARNING: UK BASAL RATES LIKELY SET HIGHER than those in Pankowska study)
Physical activity (based on time, intensity, duration and % advice given) and illness correction (self chosen % reduction)

Other features: Tracks injections sites/finger prick sites.

American databases. Can add own products and portions to database of food, Premium users can analyse home recipes. Edamam will be based on US food values

https://www.diabetes-m.com/blog/premium-features/how-to-analyze-your-recipes-nutrition-values-with-diabetesm

American databases linked in for food, US foods only in FatSecret: Food & Diet management service, USDA (US Dept Agriculture), BEDCA (Spanish Food Comp database)

Screenshot 1: 5.2. Active insulin

Diabetes:M User's Guide

5.2. Active insulin

Diabetes:M calculates Active Insulin or Insulin On Board (IOB) using the following curve:

(Graph: IOB [%] vs Time [h], curves labelled 2h curve, 3h curve, 4h curve, 5h curve, 6h curve, 7h curve, 8h curve)

‹ 5.1.3. Safety check warnings   5.3. Blood glucose indexes (BGI) ›

Exit

Screenshot 2:

```
→ IOBcarb = 0
→ IOBcorr = 0

FOR all entries in the last 8 hours DO
    → Calculate *bolusPercent* from the t
ime of the entry to the current time,
        according to the IOB curve for the
selected active insulin duration

    IF entry has carbohydrates THEN
        → carbBolusIOB = min(bolus, carb
ohydrates/I:C) * bolusPercent
        → corrBolusIOB = bolus * bolusPe
rcent - carbBolusIOB

    IF entry doesn't have carbohydrates
THEN
        → carbBolusIOB = 0
        → corrBolusIOB = bolus * bolusPe
rcent

    → extendedInsulinIOB = 0

    IF entry has extended insulin THEN
        → Calculate *extendedInsulinIOB*
according its duration and current time

    → IOBcarb = IOBcarb + carbBolusIOB +
extendedInsulinIOB
    → IOBcorr = IOBcorr + corrBolusIOB
END
```

Exit

Screenshot 3:

Glucose Trend arrow adjustment

For more details and information visit
A Simplified Approach Using Rate of Change Arrows to Adjust Insulin With Real-Time Continuous Glucose Monitoring
by David C. Klonoff MD, FACP, FRCPE, Fellow AIMBE, David Kerr, MD, FRCPE

```
trendGlucose = 30 min * selectedTrendPerM
inute

trendCorrection = trendGlucose / ISF

IF trendGlucose<0 THEN
    → trendCorrection = max(trendCorrect
ion, correctionLimit)

IF trendGlucose>=0 THEN
    → trendCorrection = min(trendCorrect
ion, correctionLimit)

!! trendCorrection is negative when the t
rend is down and positive when the trend
is up
```

Trend correction limit

Exit

Screenshot 4:

Trend correction limit

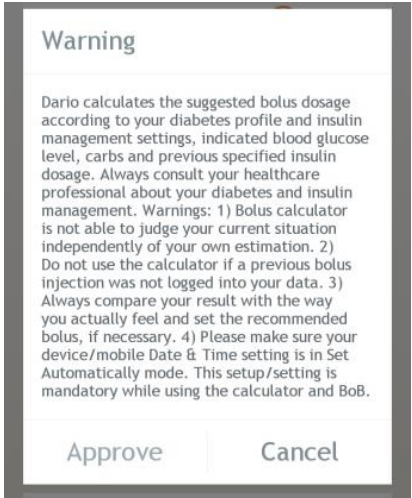| Trend arrow	Change/min (mmol/l)	Max Correction Limit (IU)
↓↓	< -0.167	-2
↓	< -0.11	-1.5
↘	< -0.06	-1
↗	> +0.06	+1
↑	> +0.11	+1.5
↑↑	> +0.167	+2

Exercise adjustment

```
exerciseBolusAdjustment = bolus * (1 - se
lectedExerciseAdjustmentInPercent / 100)
```

Sickness adjustment

```
sicknessBolusAdjustment = bolus * (1 + se
lectedSicknessAdjustmentInPercent / 100)
```

Exit

Gillian Purcell and Maria Leveridge, Specialist Paediatric Diabetes Dietitians, South West Paediatric Diabetes Network   7th May 2020

Name (manufacturer)	Age group –source of info	Meter that can directly blue tooth to calculator?	IOB	Cost	Connectivity to DIASEND	Negatives
Dario Smart Meter app My Dario https://mydario.co.uk/	No age limit found on user guide	 Mini meter has an audio connector that plugs into headphone socket of smartphone Compatible with Android and iPhone systems	**Bolus on board (BOB)**	**free**	Reports produced of the data you enter but no link to DIASEND (ML) Could not get app to share with diabetes provider 	No insulin adjustments for activity, illness Physical activity in kcals can be logged (record) to bolus but no adjustment made to dose Memory of BG tests are limited by smartphone memory capacity

Timeblocks: 4 time blocks for ICR and ISF, 0500-11.00; 11.00-16.00; 16-2300; 2300-0500. Target ranges preset

Insulin precision: 0.1 units

Active insulin: Can be set between 3.5 – 5 hours regardless of insulin type

Dose adjustment. Unclear how bolus on board (BOB) calculated

Other features: Alerts to caregiver – able to link caregiver phone.
Maximum BG 33.3mmol. Reads 'HIGH' if over. Will read 'LO' if lower than 0.5mmol. You can set a bespoke hypo warning alert.
Food database. Add own foods.
Tracks activity but in kcals. Can sync with RunKeeper – personal trainer app. Physical activity in kcals can be logged to bolus but no adjustment made to insulin dose
Reminders can be set for post meal alarms

Name (manufacturer)	Age group –source of info	Meter that can directly blue tooth to calculator?	IOB	Cost	Connectivity to DIASEND	Negatives
Hedia Diabetes Assistant (HDA) Hedia.co (Copenhagen)	Adults 18+ Won't let you proceed unless you indicate (tick) over 18	Contour Next one (via Near Field Connection - NFC) Glucomen Areo Glucmen Areo 2K	Yes	Free	The connected meters are downloadable to DIASEND An export a .pdf of data	No advice for illness *'Not advised in pregnancy, GDM or fever'*

Timeblocks: Set time blocks in daily intervals. . Can calculate using 500 & 100 rule or set own ICR/ISF. Able to set personal target BG levels within certain parameters. ICR setting maximum 50g, ISF maximum setting 10mmol
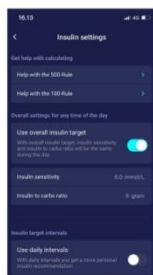
Insulin precision: 0.5-1 unit.

Active insulin: Active insulin calculated from the Novorapid time action profile for calculations.

Dose adjustment: Dose advised based on ICR/ISF; current BG, carb, activity & Active insulin. Will offer a reverse correction. Maximum carb entry 300g, can access from food database 1700 items (assume Danish foods). Favourite meals can be set up. Activity reductions advised

Other features: Automatically sets timer to remind to check BG 1.5 hours after eating. Will advise at this point if you need a correction or to consume carbohydrate. This preset can be changed to 30minutes – 6 hours at half hourly intervals
Maximum BG level 33.3mmol/L. Asks user to check ketones is above 15mmol & activity is planned. Plus recheck BG in two above 15mmol in 6 hour intervals
Maximum insulin dose recommendation 50 units

In "Insulin settings" you can set your insulin settings for the day using:
- an overall setting for insulin sensitivity factor and insulin-to-carb ratio (use overall insulin target) or
- you can set your daily intervals for insulin sensitivity factor and insulin-to-carb ratio (use daily intervals)

Insulin sensitivity factor and insulin-to-carb ratio can be adjusted in insulin settings for both "Overall insulin target" and for "Daily intervals".

Table 13: Limits for adjusting the insulin sensitivity factor and insulin-to-carb ratio

	mmol/L	mg/dL
Insulin sensitivity factor	- Minimum 0.3 mmol/L - Maximum 10 mmol/L	- Minimum 1.5 mg/dL - Maximum 50 mg/dL
Insulin-to-carb ratio	- Minimum 1 g carbohydrates per unit of insulin - Maximum 50 g carbohydrates per unit of insulin	- Minimum 1 g carbohydrates per unit of insulin - Maximum 50 g carbohydrates per unit of insulin

When using "Daily intervals" both insulin sensitivity factor and insulin-to-carb ratio is the same for all seven time periods and is based on your settings from the log-in process.

The default settings for daily intervals in HDA is divided into seven time periods throughout the day as seen below (table 14):

Table 14: Default settings for the seven periods in HDA

No.	Time period	Time of day
1.	00:01 - 05:00	Night
2.	05:01 - 09:00	Morning
3.	09:01 - 11:00	Before lunch
4.	11:01 - 13:00	Lunch
5.	13:01 - 18:00	After lunch
6.	18:01 - 22:00	Evening
7.	22:01 - 00:00	Bedtime

---

6. Insulin

HDA's calculations are based on a fast-acting insulin analogue. The 'Insulin recommendation' page in HDA shows the calculations for HDA's recommendations.

This calculation shows how many units of insulin HDA recommends. In addition, active insulin appears in the calculations. It is important that you as a user check HDA's calculations before approving a dose.

6.1. Active insulin

Active insulin tells how many units of rapid acting insulin are left in the body and still working. HDA automatically calculates the amount of active insulin and displays it on the dashboard and on the 'insulin recommendation' page. HDA takes into account active insulin in its calculations.

HDA uses the Novorapid curve for these calculations. The maximum plasma concentration of Novorapid is reached after 30-40 minutes (Ref. 3).

The effect on blood glucose concentration occurs 10-20 minutes after subcutaneous injection and is maximal between 1 and 3 hours. Duration is 3-5 hours, depending on dose (1). HDA's calculations thus look like this (table 5):

Table 5: Insulin effect curve

Insulin effect curve					
Time (hours)	1	2	3	4	5
Percentage (%)	29	47	19	5	0

The curve is furthermore divided into 4 x 15 min for the first hour and 2 x 30 min for the next 3 hours to make calculations based on the most precise amount of active insulin as possible (Ref. 4, 5).

If the user has not documented any bolus insulin within the last 4 hours, HDA asks: *Have you taken insulin within the last 4 hours?* If yes, the user is asked to enter the amount of insulin injected within the last 4 hours.

6.2. Maximum insulin dose

HDA is set with a limit on how much insulin the app recommends. This maximum is 50 units for one administration/in one dose. The limit also apply to manual entries and are a precautionary measure to avoid unintentionally large doses.

---

7. Activity

In HDA you can add your activity to the calculation of your insulin recommendation, either before or after an activity.

7.1. Activity levels in HDA and their effect

To rate your perceived exertion HDA uses "The Borg Rating of Perceived Exertion" which is a way of measuring your physical activity intensity level.

Perceived exertion is how hard you feel like your body is working. It is based on the physical sensations you experience during physical activity, including increased heart rate, increased respiration or breathing rate, increased sweating, and muscle fatigue. Although this is a subjective measure, your exertion rating may provide a fairly good estimate of your actual heart rate during physical activity.

Always consult your physician before beginning any activity. This general information is not intended to diagnose any medical condition or to replace your healthcare professional. Consult with your healthcare professional to design an appropriate exercise prescription. If you experience any pain or difficulty during activity, stop and consult your healthcare provider.

7.1. Activity levels in HDA and their effect

To rate your perceived exertion HDA uses "The Borg Rating of Perceived Exertion" which is a way of measuring your physical activity intensity level.

Perceived exertion is how hard you feel your body is working. It is based on the physical sensations you experience during physical activity, including increased heart rate, increased respiration or breathing rate, increased sweating, and muscle fatigue. Although this is a subjective measure, your exertion rating may provide a fairly good estimate of your actual heart rate during physical activity.

Always consult your physician. This general information is not intended to diagnose any medical condition or to replace your healthcare professional. Consult with your healthcare professional to design an appropriate exercise prescription. If you experience any pain or difficulty during activity, stop and consult your healthcare provider.

7.2. How HDA calculates the effect of activity

Tabel 6: Calculated effect of activity in HDA

Duration	Intensity			
	Light exercise	Medium exercise	Hard exercise	Post exercise
0-29 minutes	0 %	0 %	0 %	0 %
30-45 minutes	25 %	50 %	75 %	50 %
46-60 minutes	50 %	75 %	— Tekst —	50 %
More than 60 minutes	Consult healthcare professional			
Starting target BGL	9 mmol/L or 162 mg/dL			

7.3. Duration of activity

When using the activity module in HDA the circular slider can set the time spend on exercise up to 60 minutes.
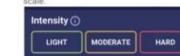
7.4. Type of activity

After setting the duration of your activity, you can add the type of activity you have performed. You do this by clicking on the icon below the circular slider.

7.5. Intensity of activity

The next step is to enter how intense your exercise is going to be/were. You do this by pushing "light, moderate or hard". The chosen intensity enables the activity effect on the insulin algorithm.

Next to intensity you'll see an "i" in a circle, push the icon for more information related to the use of the BORG scale.

7.6. Activity start, title and recommendation

When you add activity, you can log this in advance, or log it after.
Activity will only affect the first calculation made after the start time of the activity. However, only if this calculation is made within 4 hours from the start time of the activity.