Evaluation of a novel tool to adjust insulin boluses based on CGM trend arrows (Trend Arrow Adjustment Tool) in Children and Youth with Type 1 Diabetes using Insulin Pump Therapy

E. Heffernan[1,2] M. L. Lawson[1,2] C. Richardson[2], J. Courtney[2], B. Bradley[2] JDRF Canadian Clinical Trial Network CCTN1101 and the CGM TIME Trial Study Group
[1]Children's Hospital of Eastern Ontario, Ottawa, Canada [2]CHEO Research Institute, Ottawa, Canada

Abstract

- **Continuous Glucose Monitoring** (CGM) measures interstitial glucose and displays trend arrows.
- **Trend Arrows** provide dynamic data on the **direction & rate of change of glucose**, and provide an opportunity to make adjustments to prevent hypo and hyper-glycaemia.
- Effective strategies for adjusting insulin for trend arrows are lacking.
- The JDRF CGM Study Group recommended a **10/20% adjustment** (10% for 1 arrow; 20% for 2 arrows). Bolus dose is increased for up arrows, and decreased for down arrows. This requires a mathematical calculation with each arrow, limiting the tool's uptake in paediatrics.
- We developed a **Trend Arrow Adjustment Tool**, based on the **insulin sensitivity factor (ISF)**. The child only needs to remember 2 numbers, the adjustment for 1 arrow and the adjustment for 2 arrows

Trend Arrow Adjustment Tool

ISF mmol/L	↓ or ↑ (units insulin)	↑↑ or ↑↑ (units insulin)
1	1.5	3
1.5	1	2
2	0.75	1.5
2.5	0.6	1.2
3	0.5	1
3.5-4	0.4	0.8
4.5-5	0.3	0.6
5.5-6	0.25	0.5
7-8	0.2	0.4

CGM Trend Arrows	10/20% method JDRF CGM Study Group	CGM TIME Trial TAAT ISF = 3
↑	Add 10% to bolus	Add 0.5 units (1.5÷ISF=1.5÷3 = 0.5)
↑↑	Add 20% to bolus	Add 1 unit (3.0÷ISF= 3÷3 = 1)
↓	Subtract 10% from bolus	Subtract 0.5 units (1.5÷ISF=1.5÷3 = 0.5)
↓↓	Subtract 20% from bolus	Subtract 1 unit (3.0÷ISF=3.0÷3 = 1)

Objectives

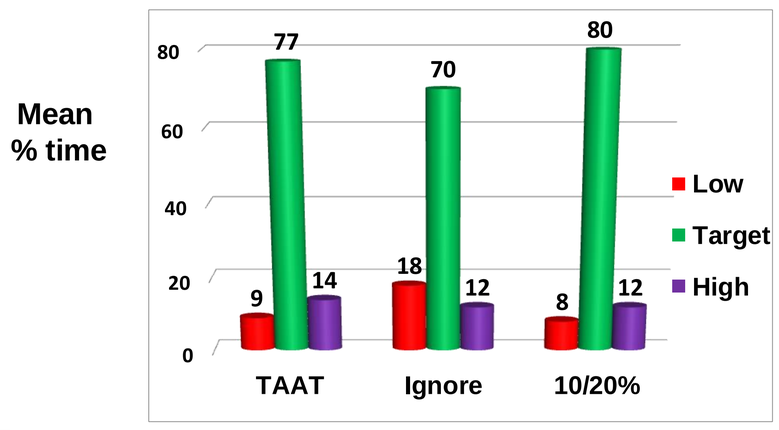
- Compare the effect of the Trend Arrow Adjustment Tool, the 10/20% adjustment, and making no adjustment for arrows; on achieving postprandial glucose targets.
- Evaluate satisfaction, ease of use, error rates and preferred method for future use of both adjustment methods

Methods

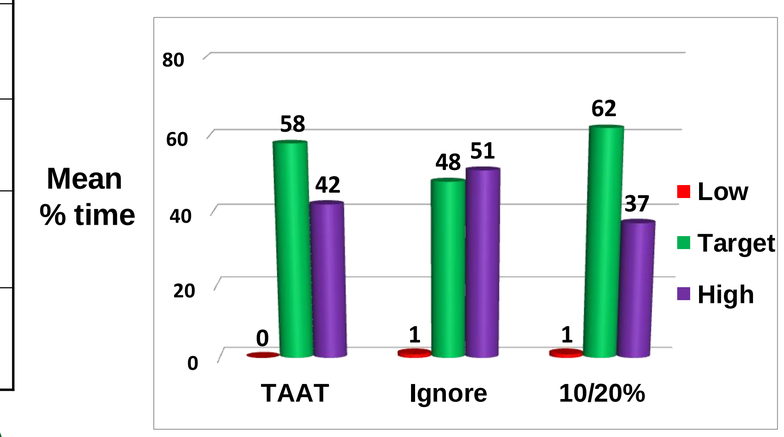
- Counterbalance crossover study
- 20 subjects from CHEO diabetes clinic
- Eligibility criteria:
  - Age 5-18 yrs
  - Type 1 diabetes > 1 year
  - Use of pump and CGM for > 3 months
- **Hospital visit – trend arrows triggered** through exercise /juice. Standardised meal with insulin bolus adjusted for arrows using TAAT/10/20%
- **Home based assessment-** subjects used TAAT/10/20%/ignored arrows for 1 week each, arrows recorded in logbook
- Carelink used to collect **sensor glucose data for 4 hours after each arrow**
- Analysed to determine % time glucose
  - **in target** 4-10mmols/l
  - **low** < 3.9mmols/L;
  - **high** >10.1mmols/L

Results

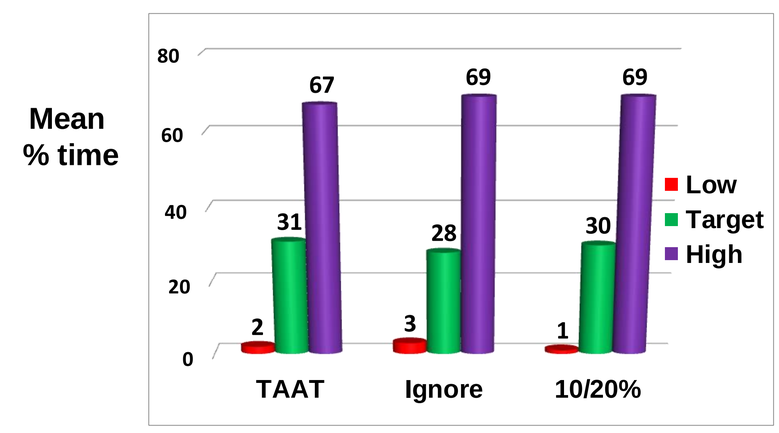
Postprandial glucose, when starting sensor glucose was ≤ 8 mmol/L



Postprandial glucose, when starting sensor glucose was 8-12 mmol/L



Postprandial glucose, when starting sensor glucose was >12 mmol/L



Results

Demographics

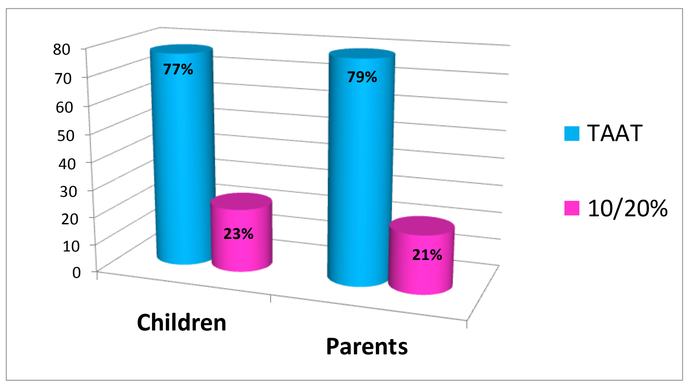
Gender	n	%
Female/Male	8/12	40/60
	Mean	Range
Age, years	12.7	7 - 17
Duration diabetes, years	5.7	2 - 15
Duration pump use, years	2	0.3 - 3.3
Duration CGM use, years	1.8	0.3 - 3.3
HbA1c %	7.4	5.3 - 10.6
CGM use pre study, % of time	67	0 - 100
BMI Z score	0.86	-0.47 +2

Details of tool use

	TAAT	Ignore arrows	10/20%
Total uses	85	85	70
Uses per patient per week, mean (range)	4.3 (0-10)	4.3 (0-11)	3.5 (0-7)
Mean adjustment (max) units of insulin	0.65 (2)	–	0.84 (3.5)
Errors n (%)	1 (1.3)	–	17* (24)
Mean error (max) units of insulin	0.25 (0.25)	–	0.62 (2.6)

*p <0.001 Fishers exact test

Which tool will you use in future?



Conclusions

- TAAT as effective as 10/20% adjustment. in achieving postprandial glucose targets
- Trend towards less hypoglycaemia with use of either tool vs ignoring arrows.
- Significantly fewer errors when TAAT used compared to 10/20% method
- TAAT was the preferred method for future use by children/youth and parents
- TAAT is a simple, well received method of adjusting insulin for CGM trend arrows.

References

1. Technology to Optimize Diabetes Outcomes. *Current Diabetes Report*, 2013
2. The role of CGM in the care of children with type 1 diabetes. *International Journal of Pediatric Endocrinology,* 2013
3. An algorithm guiding patient responses to real time continuous glucose monitoring improves quality of life. *Diabetes Technology & Therapeutics*, 2011
4. What are the quality of life-related benefits and losses associated with real-time continuous glucose monitoring? A survey of current users. *Diabetes Technology & Therapeutics*, 2013
5. Use of DirectNet Applied Treatment Algorithm (DATA) for diabetes management with a real time continuous glucose monitor. *Pediatric Diabetes,* 2008
6. How people use direction and rate of change information provided by real time continuous glucose monitoring to adjust insulin dosing. *Diabetes*. Continuous glucose monitoring and intensive treatment of type 1 diabetes. *New England Journal of Medicine,2008*

Study supported by JDRF Canadian Clinical Trials Network, Postdoctoral Fellowship in Clinical Translation in T1 D and E. Heffernan was supported by JDRF UK, donation by Ruth Gillespie Family