

# Use of iButton Sensors to measure children's skin temperature during sleep in the home setting

Susan McCabe<sup>1</sup>, Chris Abbiss<sup>1</sup>

<sup>1</sup> Edith Cowan University, Perth, Western Australia; Corresponding Author: sue.mccabe7@gmail.com

## Background

Good sleep is fundamental to all aspects of children's and their caregivers' health, development, learning and participation.<sup>1,2,3,4</sup>

Distal and proximal skin temperature (Tsk) and the distal-proximal gradient (DPG) are important in sleep onset and maintenance.<sup>5,6,7</sup>

Thermochron iButtons are valid measures of human skin temperature in controlled settings.<sup>8</sup>

This study determined the practical application and reliability of iButtons to measure children's skin temperature during sleep in their home settings, with their usual routines and activities.

## Methods

- 23 children (aged 6-12 y) over four consecutive nights
- iButtons set to record at 5-minute intervals
- secured to skin with surgical tape, one hour before bedtime
- no restrictions to usual routines and activities
- measured **distal Tsk** (L + R feet), **proximal Tsk** (L + R thigh, L + R subclavicular area, abdomen), and **forehead Tsk**
- actigraphy and diaries to record activities and timing of bedtime, sleep onset and waking



## Results

- All children tolerated the use of iButtons with surgical tape; 3 reported skin irritation at subclavicular area.
- Distal Tsk was lower, and changed more rapidly, than proximal Tsk before bedtime, at reported bedtime and for two hours AB. This caused corresponding changes in DPG.
- Reliability of Proximal Tsk was good (CV<0.9%) when viewed across the entire sleep period. Forehead Tsk was less reliable (CV>1.2%) around BB, RB and SO. Distal Tsk, and thus DPG, were less reliable (CV>2.4%) around BB, RB and SO.
- Interesting to note forehead Tsk in relation to distal Tsk and proximal Tsk.

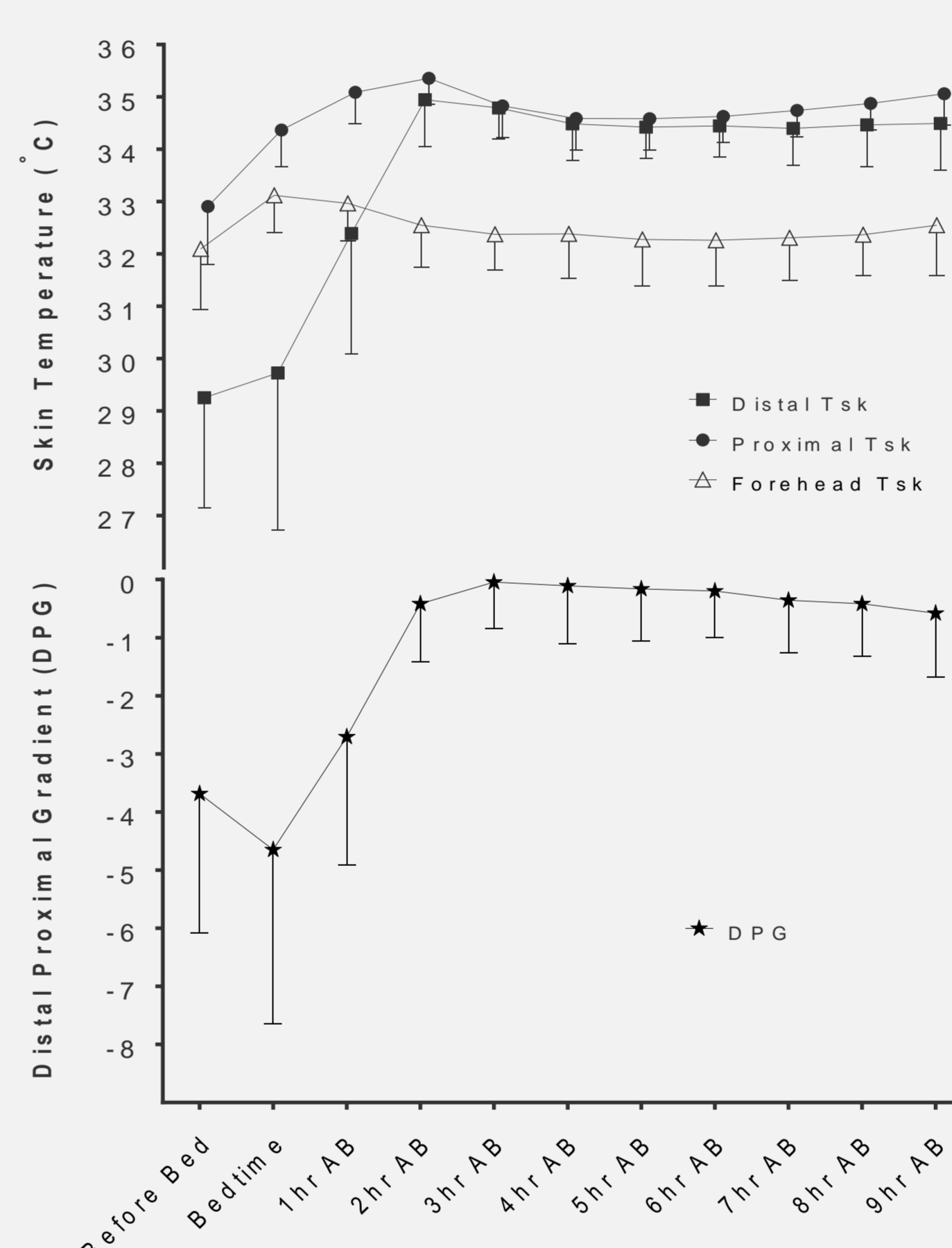
Night-night reliability  
Mean hour measures: across whole night

	Raw TE (90%CL)	Raw ICC (90%CL)	LOG CV (90%CL)
Distal Tsk	0.46 (0.39-0.56)	0.63 (0.44-0.79)	1.4 (1.2-1.7)
Proximal Tsk	0.3 (0.26-0.36)	0.44 (0.23-0.65)	0.9 (0.7-1.1)
DPG Tsk	0.55 (0.47-0.68)	0.57 (0.37-0.75)	Not available
Forehead Tsk	0.33 (0.29-0.41)	0.76 (0.61-0.87)	1.0 (0.9-1.3)

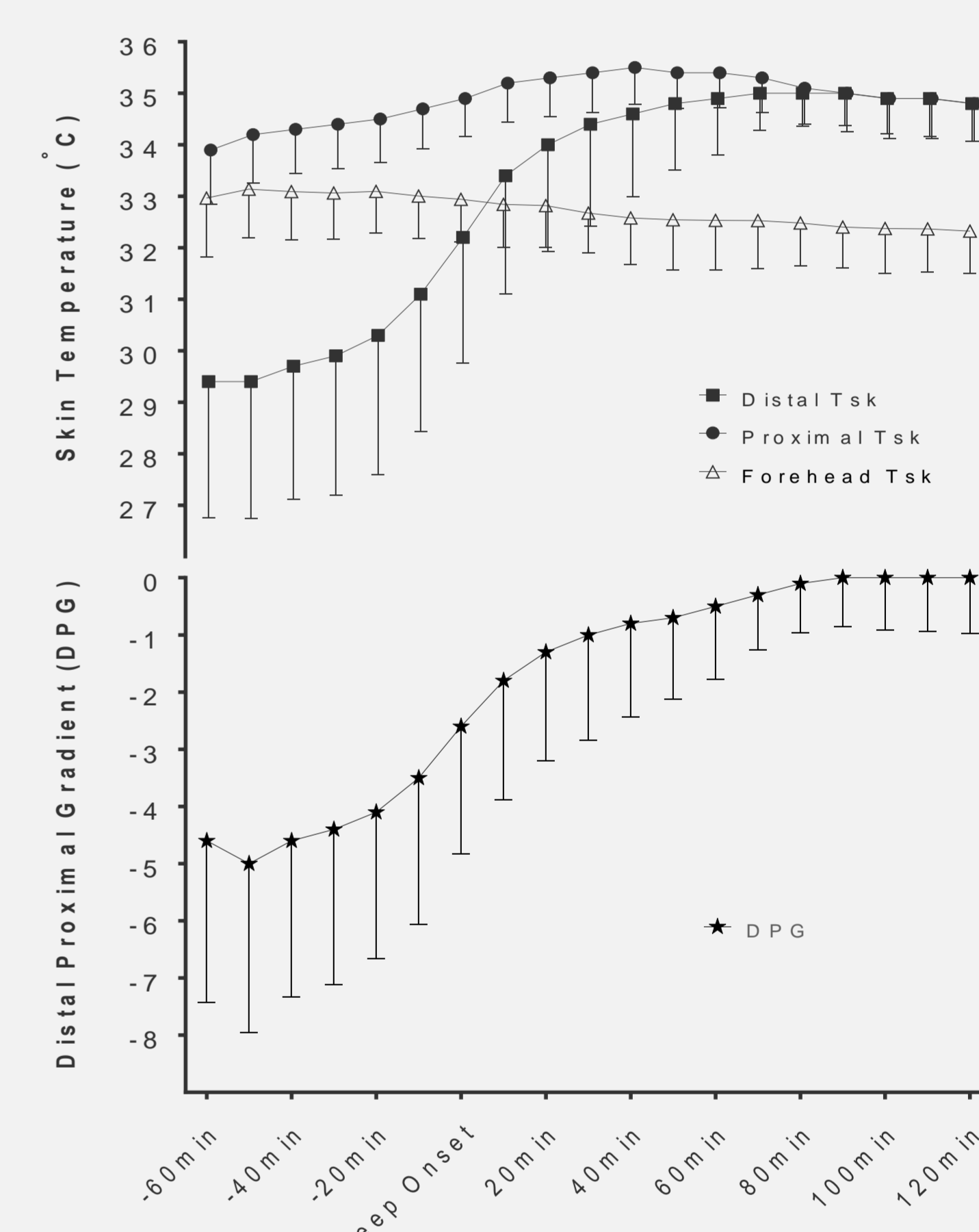
Night-night reliability  
Mean 10 minute measures: before and after sleep onset

	Raw TE (90%CL)	Raw ICC (90%CL)	LOG CV (90%CL)
Distal Tsk	0.77 (0.66-0.94)	0.62 (0.44-0.78)	2.4(2.1-3.0)
Proximal Tsk	0.3 (0.26-0.37)	0.68 (0.51-0.82)	0.9 (0.7-1.1)
DPG Tsk	0.84 (0.72-1.02)	0.63 (0.45-0.79)	Not available
Forehead Tsk	0.38 (0.32-0.46)	0.71 (0.54-0.84)	1.2 (1.0-1.4)

Distal Tsk, Proximal Tsk, Forehead Tsk and DPG  
1 hour averages, before and after bedtime, entire night



Distal Tsk, Proximal Tsk, Forehead Tsk and DPG  
10minute averages, 60mins before SO to 120mins after SO



## Analysis

Tsk hour intervals: before bedtime (BB), at reported bedtime (RB), at sleep onset (SO), for 9 hours after bedtime (AB).

Tsk 10-minute intervals: 60 minutes before and 120 minutes after sleep onset (SO).

Reliability night- night: two-way analysis of variance, typical error (TE), intra-class correlation (ICC) and coefficient of variation (CV).

## Conclusions

- Thermochron iButtons provide reliable measure of children's skin temperature during sleep in their home settings.
- Reliability is higher across the entire night, and for proximal Tsk.
- Lower reliability for distal Tsk at pre-sleep, bedtime and sleep onset may be due to night-night inconsistencies in children's pre-sleep activities and environments.
- It is difficult to control for the many and varied factors in the home setting.
- These findings have implications for sleep research relating to children's skin temperature in their home settings.

## Practical considerations

Label iButtons clearly to ensure correct placement on skin site. Nail polish can be used to mark the iButtons (everything else comes off).

Consider risk of ingestion – avoid placing iButtons on children's hands. Pre-test child's sensitivity to surgical tape.

Consider household needs, siblings' needs and evening activities when determining suitability for participation in home based studies.

Further analysis could determine need to measure at all sites (e.g. L foot + R foot, or just one foot?).



## References :

1. Hill et al. *Arch. Dis. Childhood.* 2007, 92, 637.
2. Bourke-Taylor et al. *J. Paed. Child Health.* 2013, 49, 775.
3. Bower et al. *J.Sleep Res.* 2010, 19,323.
4. Blunden & Chervin. *J Paed. Child Health.* 2010, 46, 10.
5. Abe & Kodama. *Pediatr. Int.* 2015, 57, 227
6. Krauchi & DeBoer. *Front. Bioscience.* 2010, 15, 604.
7. Romeijn et al. *Eur. J.Physiol.* 2012, 463, 169.
8. Hasselberg et al. *Sleep Med.* 2013, 14, 5.

## Acknowledgements to:

Children and families who participated in this study. Professor Catherine Elliott and Dr Katherine Langdon, for clinical supervision of this study.