Distal skin vasodilation precedes sleep onset in preterm neonates and children

BACH Véronique[1], McCABE Susan[2], ABBISS Chris[2], BARCAT Lucile[1,3], TOURNEUX Pierre[1,3]

[1] PeriTox, UMR_I 01 University of Picardy Jules Verne, Amiens, France, [2] School of Medical and Health Sciences, Edith Cowan University, Australia [3] Pediatric Intensive Care Unit, CHU Amiens, France

Introduction

A vegetative sleep preparedness has been described in adults during the 100 min before sleep onset, with distal skin vasodilation increasing body heat loss. Sleep onset occurs when core body temperature is decreasing. As a result, promoting distal vasodilation, particularly in hands and feet, increases sleep propensity. The gradient of distal-to-proximal skin temperature (Ts) which features distal skin vasodilation has been demonstrated to be the best predictor for rapid sleep onset. To our knowledge, this process has not been examined in across development.

Therefore, we assessed the evolution of Ts before sleep onset (1) in 9-days old preterm neonates and (2) in children aged 6-12 years.

Subjects and methods

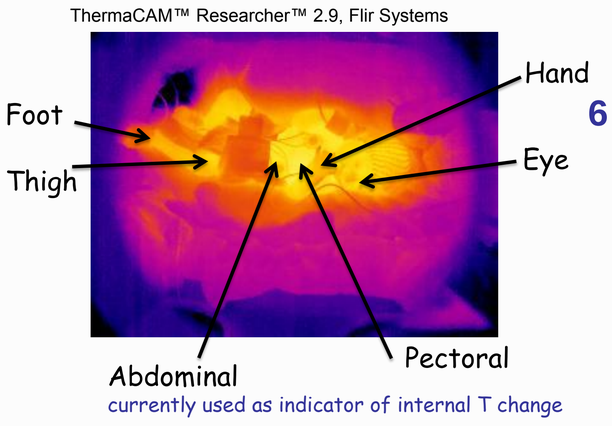
Neonates study

29 neonates
- 9 days old
- Postconceptional age: 208±8 days
- Birth weight: 1331±343 g

Overnight polysomnography (EEG, EOG)
- 12hrs, 8pm – 8am,
- incubator air temperature: 32.7 ± 1.4C

Scoring
- spontaneous **Wakefulness (WASO)**
- Sleep - Active, Intermediate, Quiet

ThermaCAM™ Researcher™ 2.9, Flir Systems



currently used as indicator of internal T change

6 skin temperatures (T, infrared thermography)
- Measured at the **beginning** and the **end**, and **every 5 min** during 117 spontaneous WASO (15±9 min, 2-95 min)

Average values of cutaneous T and of their differences with abdominal T (**TPD**) were calculated during each WASO episode

Children study

23 children
- Age 6-12 years
- Typically developing
- In their home setting
- No restrictions to usual routines

Skin temperature (thermochron iButtons)
- Distal (L and R feet)
- Proximal (abdomen, L and R subclavicle area)
- Forehead

Actigraphy
- Diary for reported bedtime (RB)
- Actigraphy for sleep onset (SO)

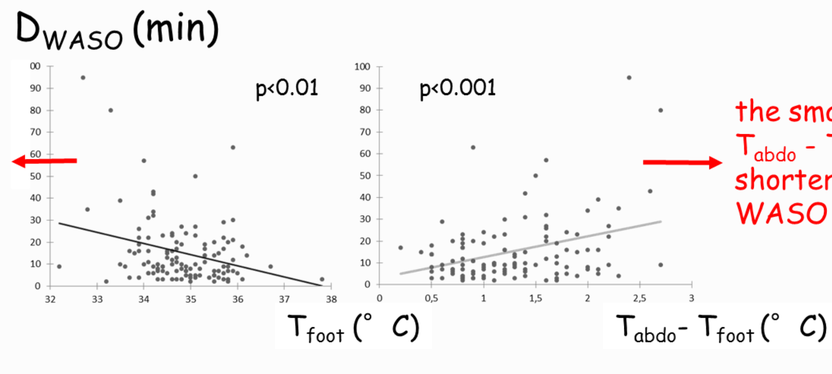
4 consecutive nights (mean skin temperatures)
- From I hour before bedtime,
- At reported bedtime (RB)
- At sleep onset (SO)
- Across 9 hrs after reported bedtime

Results

		T_{air}	Local skin temperature					
			T_{abdo}	T_{pect}	T_{eye}	T_{thigh}	T_{hand}	T_{foot}
WASO Onset	T°	ns	ns			ns		
	TPD							
During WASO	T°					ns	↘	ns
	TPD			ns		↗		
WASO end	T°					↘		
	TPD					↗		

ns: non significant, ↗ and ↘: significant positive or negative slope
(Mixed models were calculated for D_{WASO} (as the dependent variable) and Ts values (or TPDs)

- the higher the T_{foot} at the end of the WASO episod, the shorter the WASO episode.



the smaller the T_{abdo} - T_{foot} , the shorter the WASO episode

Duration of the WASO is shorter if:
- Distal skin T (hand, foot, thigh) measured during and at the end of the WASO episode are **higher** and **closer to T_{abdo}, (not observed for T at the beginning of WASO.**
- Thermal homogeneity between the 6 local T is higher at the end of the WASO episode.

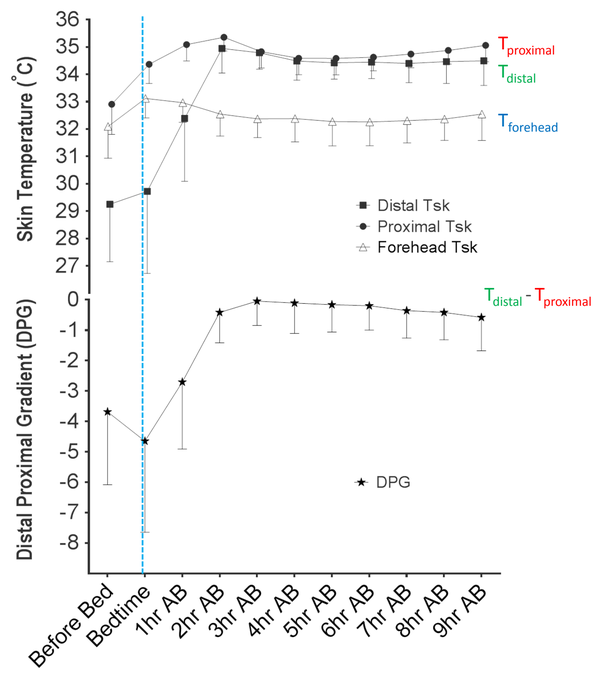
During the WASO:

-> progressive distal vasodilation during the WASO

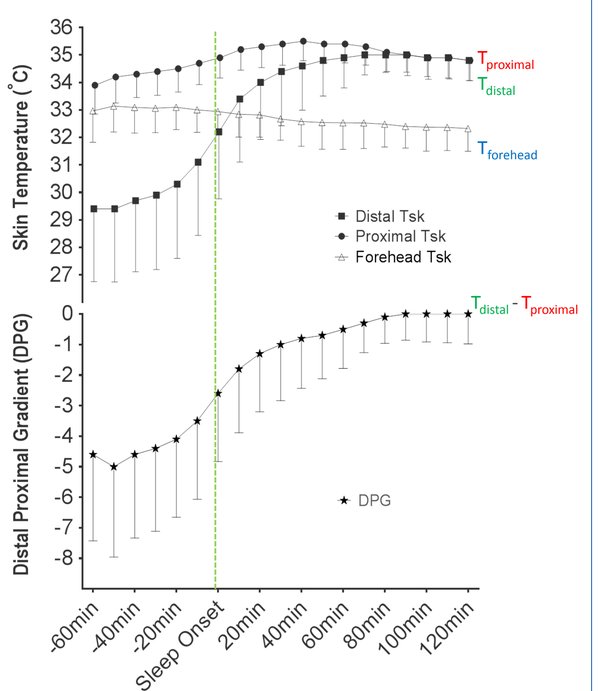
-> progressive homogeneisation of the skin T over the whole body

Results

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



Distal Tsk, Proximal Tsk, Forehead Tsk and DPG
10minute averages, 60 min before and 120 minutes after SO



Patterns of change in skin temperature are noted in relation to reported bedtime (RB) and sleep onset (SO):
- T_{distal} is lower, and rises more slowly than $T_{proximal}$ in the hour before RB, hence a dip in distal proximal gradient (DPG) in that time.
- T_{distal} rises more rapidly than $T_{proximal}$ after RB, with corresponding rise in DPG before SO.
- DPG continues to rise after SO, to reach 0 (T_{distal} = $T_{proximal}$) at around 100 minutes after SO.
- $T_{forehead}$ rises slightly in the hour before RB; it lowers prior to SO and is lower than $T_{proximal}$ at all time points.

CONCLUSION

We demonstrate for the first time that sleep is preceded by distal skin vasodilation in preterm neonates and children, which may play a key role in facilitating SO. It can be hypothesized that sleep propensity could be improved in neonates and children by mild manipulations of distal skin temperatures, as has been previously shown effective in adults.

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