SOMNEUROLAB
THE NEUROSCIENCE OF SLEEP
AT THE UNIVERSITY OF MASSACHUSETTS AMHERST

RELATIONS BETWEEN SLEEP COMPOSITIONS AND PHYSICAL ACTIVITY IN EARLY CHILDHOOD

University of Massachusetts Amherst

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Compositional Approaches for 24-Hour Movement Behavior Data Analysis: Opportunities to Rethink Standard Methods

SOCIETY OF BEHAVIORAL MEDICINE

Background

Sleep and Physical Activity

Physical activity (PA) is favorably associated with sleep in adults and adolescents (Chennaoui et al., 2015; Dolezal et al., 2017; Kredlow et al., 2015; Rubio-Arias et al., 2017)

Studies in children report inconsistent associations & components of sleep and PA are studied independently (Antczak et al., 2020; Chaput et al., 2017; Janssen et al., 2020)

Relations in preschoolers primarily focused on PA → sleep (Antczak et al., 2020; St. Laurent et al., 2021)

Sleep → Physical Activity

Limited observational studies in early childhood exploring PA as outcome → mixed results
(St. Laurent et al., 2021)

Daily association studies → some within-person associations
(St. Laurent et al., 2022a; St. Laurent et al., 2022b)

Sleep physiology (e.g., N3 sleep) could influence PA levels, but scarcely explored in preschoolers
(St. Laurent et al.; 2022c)

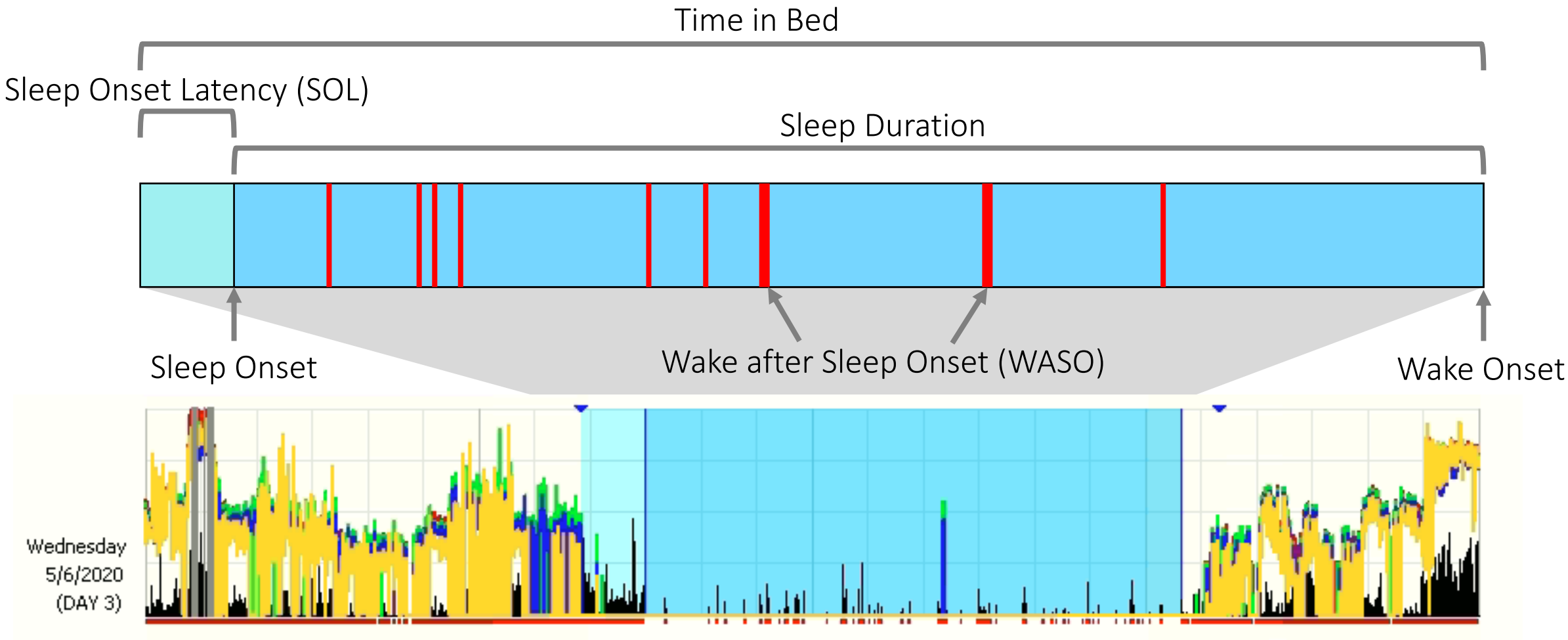
Compositional Data Analysis

A compositional data analysis (CoDA) approach can explore behaviors of the 24-hr cycle while accounting for co-dependence
(Chastin et al., 2015; Dumuid et al. 2018; Dumuid et al., 2019)

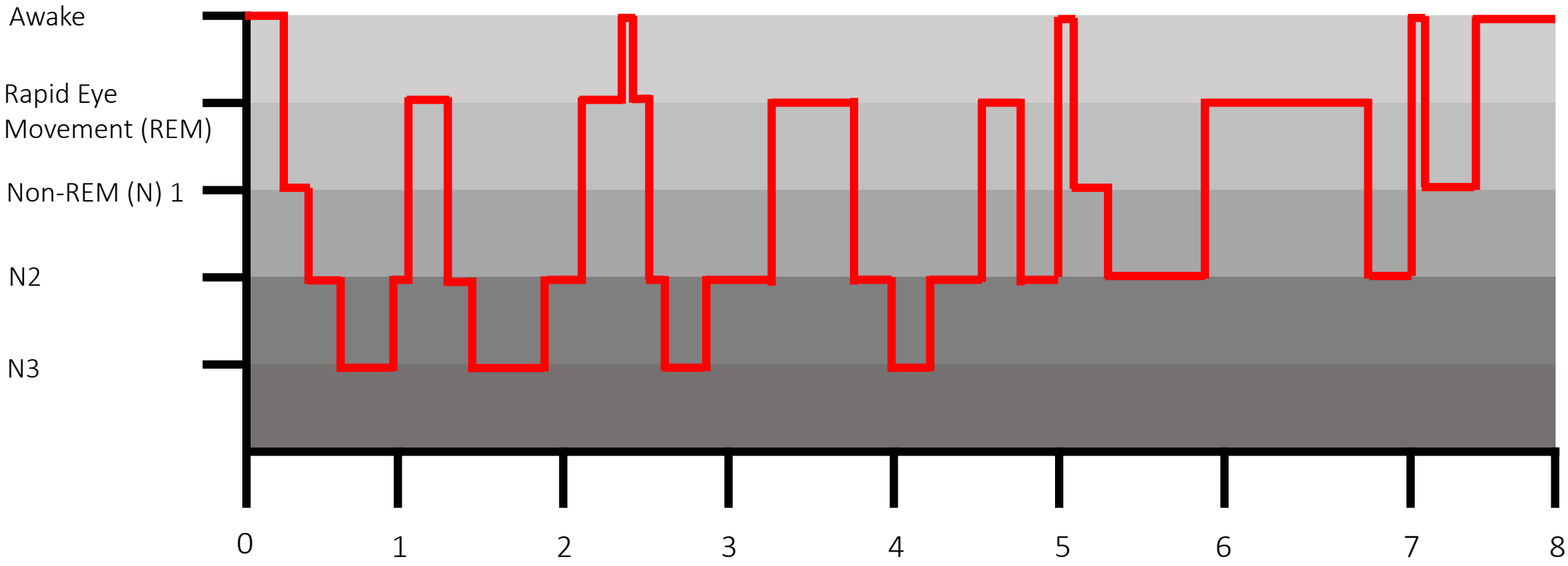
Application of CoDA in early childhood:

- Limited
- Compositions typically focused on daytime measures
- Time in bed often a proxy of sleep time
- Other sleep subcomponents not considered

Sleep Compositions (Actigraphy)



Sleep Compositions (Polysomnography)



Purpose

To determine if sleep compositions are associated with overall activity and if so, how theoretical time reallocations would influence PA levels

Question 1: Are actigraphy-measured overnight sleep compositions associated with PA in preschool children?

Question 2: Are PSG-measured nap sleep stages associated with PA in preschool children?

Methods

Participants

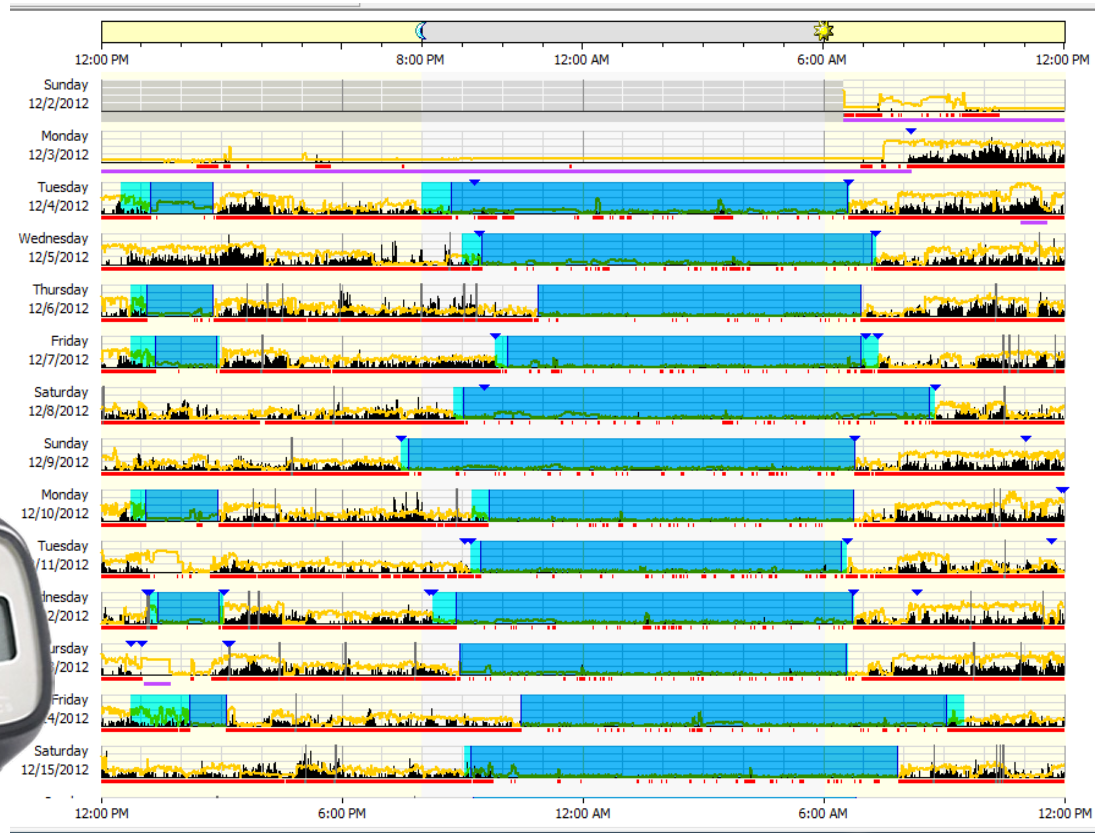
Preschool children (~3 to 5 years)

No psychotropic or sleep-effecting medications, history of neurological injury, or diagnosed developmental or sleep disorder

Minimum of 3 days & nights of actigraphy

Physical Activity

- Wrist-worn Actiwatch Spectrum devices
- Actigraphy-measured activity counts during daytime wake intervals (10.7 ± 3.6 days)
- PA = Mean counts/min



Overnight Sleep Composition

- Actigraphy-measured overnight sleep from full sample (9.6 ± 3.7 nights)
- Composition:
  - Sleep onset latency (SOL)
  - Sleep duration
  - Wake after sleep onset (WASO)

Nap Sleep Composition

- Ambulatory PSG (Embletta MRP: montage with 6 EEG, 2 EOG, 2 EMG)

- Composition:
  - SOL
  - REM sleep
  - N1 sleep
  - N2 sleep
  - N3 sleep
  - WASO

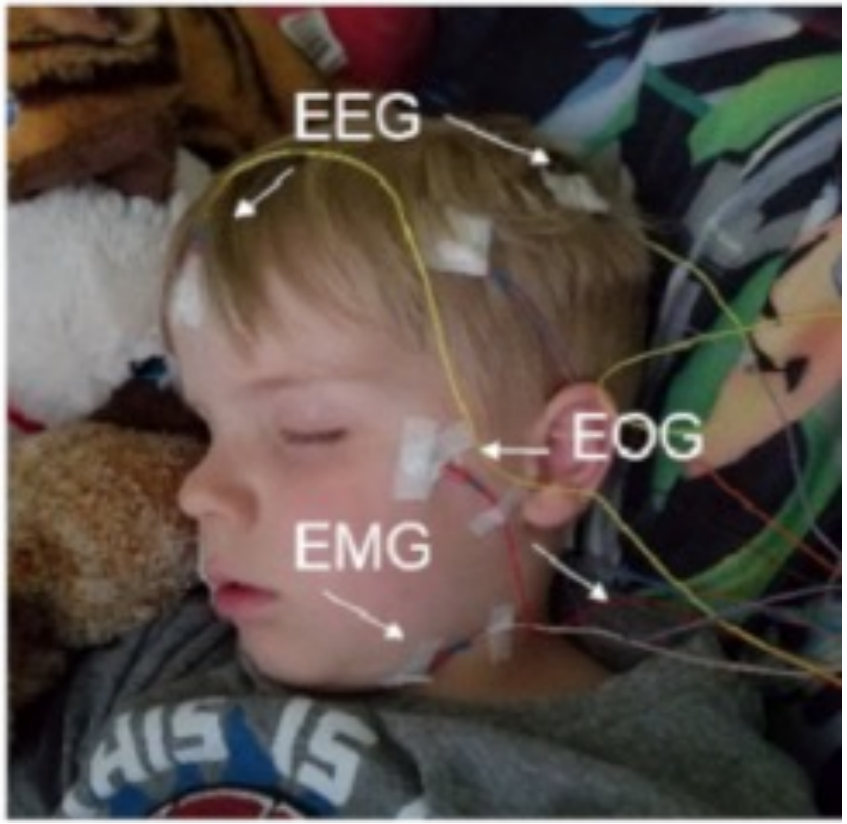


Image from Figure 1 of Allard et al., *J Vis Exp*, 2021

Converting the Compositions

- Expressing composition as ratios of its parts
  - Absolute values → isometric-log ratio (ILR) coordinates
  - # of ILRs = # of component - 1

ilr coordinate	x_1	x_2	x_3	x_4
z_1	+1	+1	−1	−1
z_2	+1	−1	0	0
z_3	0	0	+1	−1

$$z_1 = \ln\left(\frac{\sqrt{Sleep \cdot MVPA}}{\sqrt{Sedentary \cdot LPA}}\right)$$

$$z_2 = \sqrt{\frac{1}{2}}\ln\left(\frac{Sleep}{MVPA}\right)$$

$$z_3 = \sqrt{\frac{1}{2}}\ln\left(\frac{Sedentary}{LPA}\right)$$

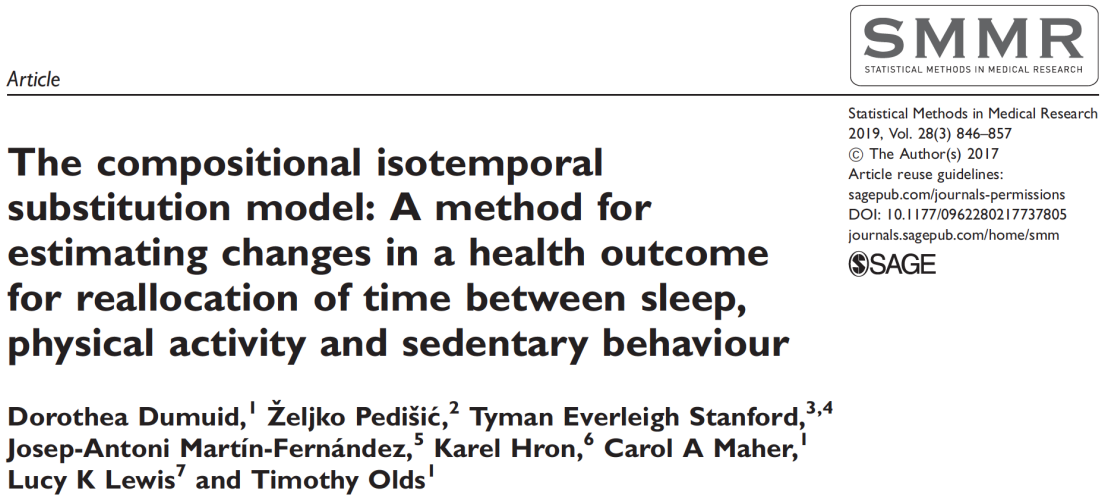
From Dumuid et al., 2019, *Statistical Methods in Medical Research* 28(3)

Analysis

Two linear regression models:
- Outcome = PA
- IV = nap or overnight sleep composition
- Adjusted for age and sex (overnight only)

Sleep metrics:
- Used simple replacement for zero values
- Transformed into isometric-log ratios (ILR) for the compositions

Isotemporal substitution:
- Estimate effects of time reallocations between sleep metrics on PA



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SAGE

The compositional isotemporal substitution model: A method for estimating changes in a health outcome for reallocation of time between sleep, physical activity and sedentary behaviour

Dorothea Dumuid,[1] Željko Pedišić,[2] Tyman Everleigh Stanford,[3,4] Josep-Antoni Martín-Fernández,[5] Karel Hron,[6] Carol A Maher,[1] Lucy K Lewis[7] and Timothy Olds[1]

van den Boogaart, K.G.; Tolosana-Delgado, R. "Compositions": A unified R package to analyze compositional data. Comput. Geosci. 2008, 34, 320–338.

The codaredistlm (formally deltacomp) R package: https://github.com/tystan/codaredistlm

Results

Participant Characteristics (Full Sample)

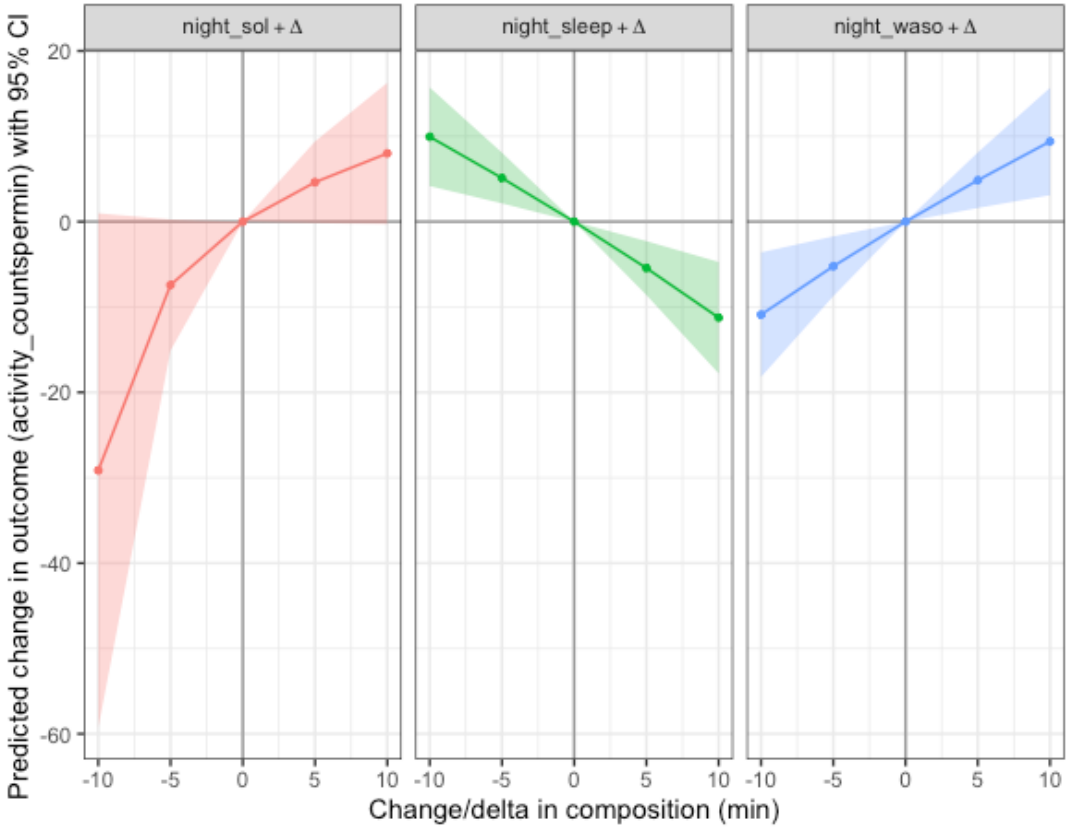
N = 432	Mean (SD) or % (n)
Age (years)	4.3 (0.7)
Sex (% female)	45.6 (197)
Race (% White)	66.8 (265)
Hispanic (%)	25.4 (103)
Nap frequency (days/week)	3.6 (2.0)
Days (#)	9.8 (3.3)
Nights (#)	10.4 (3.7)

Overnight Sleep Composition
(geometric means)

	%	min*
SOL	1.5	8.8
Sleep duration	89.9	532.2
WASO	8.6	51.0

*Based on mean time in bed of 592 min

Overnight Sleep Metrics & Physical Activity



+	Comp.	Δ	95% CI
5 min	Sleep	-5.4	-8.6 to -2.2
5 min	WASO	4.9	1.6 to 8.1
10 min	Sleep	-11.2	-17.8 to -4.7
10 min	WASO	9.4	3.1 to 15.7

Participant Characteristics (Sub-Sample)

N = 44	Mean (SD) or % (n)
Age (years)	4.2 (0.6)
Sex (% female)	54.5 (24)
Race (% White)	73.7 (28)
Hispanic (%)	8.1 (3)

Nap Sleep Composition		
	%	min*
SOL	11.7	14.6
N1	5.9	7.3
N2	26.0	32.5
N3	40.3	50.4
REM	0.1	0.2
WASO	16.0	20.0

*Based on mean nap time in bed of 125 min

Nap Sleep Stages & Physical Activity

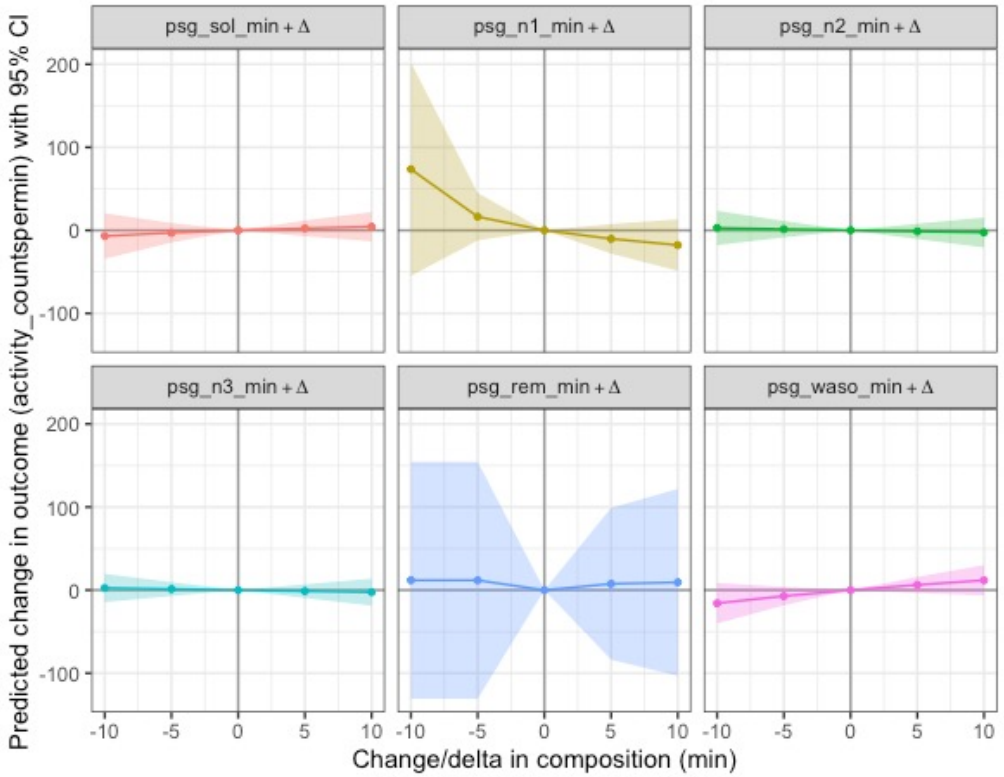
Participants with REM included (n = 9)
(using zero replacement)

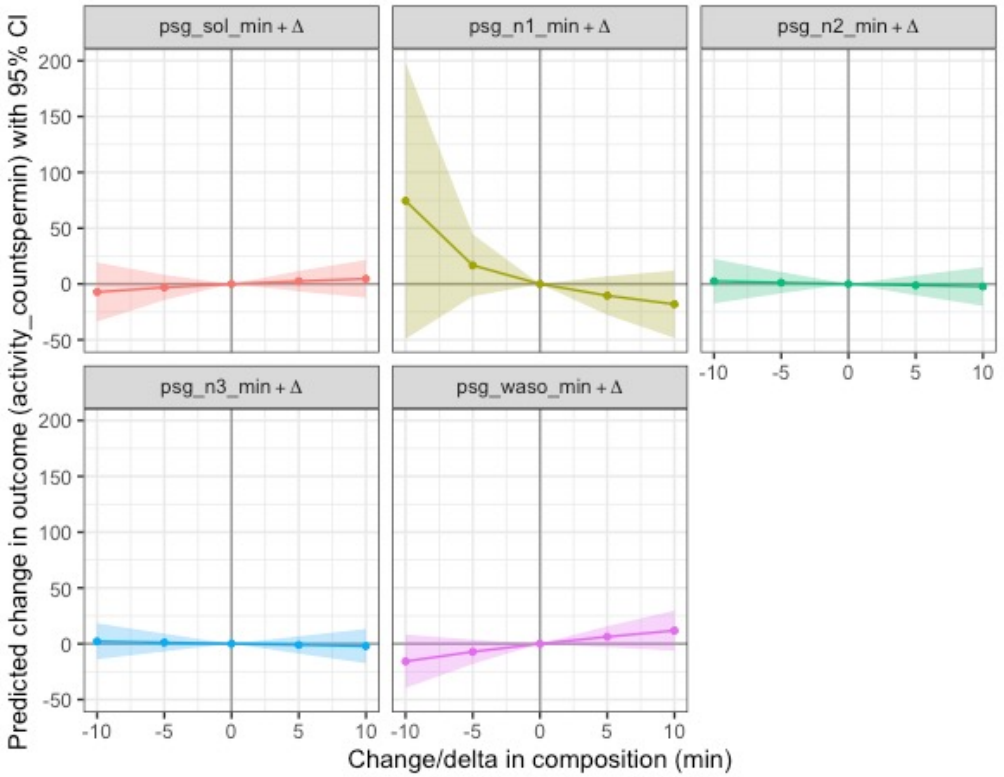
	Sum Sq	Df	F	P-value
ilr comp	32,588	5	0.5462	0.7400
age	6,979	1	0.5848	0.4499
sex	32,349	1	2.7108	0.1092

Participants with REM excluded

	Sum Sq	Df	F	P-value
ilr comp	42,957	4	0.8492	0.5062
age	4,859	1	0.3842	0.5404
sex	35,455	1	2.8036	0.1052

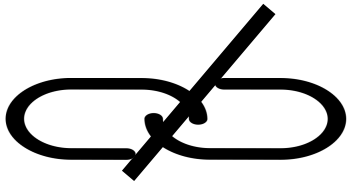
Nap Sleep Stages & Physical Activity





Conclusions & Future Directions

Conclusions



Conclusions

Considerations and Future Directions

Limitations

- Generally healthy samples
- PSG sub-sample lacked diversity in race/ethnicity & SES
- Misclassification of measures
- Cross-sectional design

Next Steps

- Health ‘diverse’ populations
- Examine 24-hr sleep compositions
- Stratify by nap habituality
- Consider other indicators of PA

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Thank You and Questions

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