

*Do novice crawling and walking
infants practice skill-relevant
movements during night wakings?*

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Changes related to infant locomotion

- Infants are “active participants in their own learning” (Spencer et al., 2006)
- Locomotion sparks significant changes to the infant’s cognitive world (Campos et al., 2000)
 - Kicking movements increase in frequency just before the onset of locomotion and rocking on hands and knees appears just before infants can crawl (Thelen, 1981)
 - The onset of locomotion changes how parents act with infants (Campos et al., 2000) and changes where infants look (Kretch et al., 2014)

Sleep changes and motor development

- Higher scores on a standardized gross-motor checklist predict greater sleep fragmentation (Scher, 2005)
- Crawling infants wake more during the night than same-aged infants who cannot yet crawl (Scher & Cohen, 2005)
- Pulling-to-stand disrupts sleep in infants that acquire it at an early age (Atun-Einy & Scher, 2016)
- Different motor milestone onsets are related, temporally, to a decrease in sleep duration and increase in night wakings (Berger & Moore, in press)

Why might skill-relevant movements happen during the night?

- Infants, especially younger infants, exhibit many bouts of gross body movements and limb movements during sleep (Fukumoto et al., 1981)
- Infants who sleep on their backs show delays in rolling, tripod sitting, creeping, crawling, and pulling-to-stand (Davis et al., 1998)
- Restricting movement in older infants may delay development of postural and locomotor skills (Adolph & Robinson, 2015)
 - If restriction at night leads to motor delays, motor activity in the crib at night may be important for motor development

Current Study

Method

Participants

- Two crawling infants (ages at crawling = 256 days and 245 days) and one walking infant (age at walking = 326 days) were included in the current longitudinal case study

Procedure

- Infants were enrolled in a study in which sleep was monitored longitudinally using the Nanit Home Baby Monitor
- Motor milestone onsets were recorded using daily parent diaries, and dates determined which nights of video were examined
- Nights of interest were the nights before, of, and after the day of milestone acquisition

Method

Data coding

- Videos collected from the Nanit crib monitor were coded using Datavyu
- Instances and durations of locomotor movements, postural shifts, and limb movements were coded during infants' wake episodes
- Wake episodes were identified as bouts of time where there was one identifiable movement per at least every 3 minutes for a total duration of at least 5 minutes. They were only coded if they occurred at least 10 minutes after initial sleep onset (Goodlin-Jones et al., 2001)

Coding manual

Movement code	Definition
<i>Arms</i>	Bout of continuous arm movement lasting for ≥ 5 seconds
<i>Legs</i>	Bout of continuous leg movement lasting for ≥ 5 seconds
<i>Mixed arms & legs</i>	Bout of continuous arm and leg movements lasting for ≥ 5 seconds
<i>Leg lifts</i>	Infant raises legs up in air while supine; sustains against gravity
<i>Sleep position shifts</i>	Any combination of shifting from one of these postures to another: prone, supine, side, bum in the air
<i>Sitting posture shift</i>	Infant shifts into a sitting posture
<i>Rocks while sitting</i>	Infant rocks whole body back and forth while in stable sitting posture
<i>Hands-knees propping</i>	Infant props self up on hands-and-knees
<i>Rocks on hands-knees</i>	Infant rocks whole body back and forth while supported on hands-and-knees
<i>Pushups</i>	Infant shifts in and out of hands-knees posture more than once in quick succession
<i>Standing</i>	Infant stands up independently
<i>Bellycrawling</i>	Infant maneuvers while on bell (no hands-knees)
<i>Crawling</i>	Infant crawls on hands-and-knees

Results (1)

Due to small sample size, significance tests were not run. Descriptive statistics were presented instead.

	Crawling < 10 ft. (<i>n</i> = 2)			Walking < 10 ft. (<i>n</i> = 1)		
	Before	Of	After	Before	Of	After
Total wake mins (<i>SD</i>)	31.01 (19.18)	61.25 (1.78)	50.40 (19.57)	10.03	22.55	14.86
Number of different movements (<i>SD</i>)	6.00 (2.83)	10.50 (3.54)	6.00 (1.41)	5.00	12.00	5.00
Movements per wake minute (<i>SD</i>)	1.52 (1.02)	1.65 (0.23)	1.36 (0.19)	2.39	4.66	1.88

Total wake minutes were calculated based on behavioral coding criteria.

Number of different movements were the variety of movements based on original coding criteria.

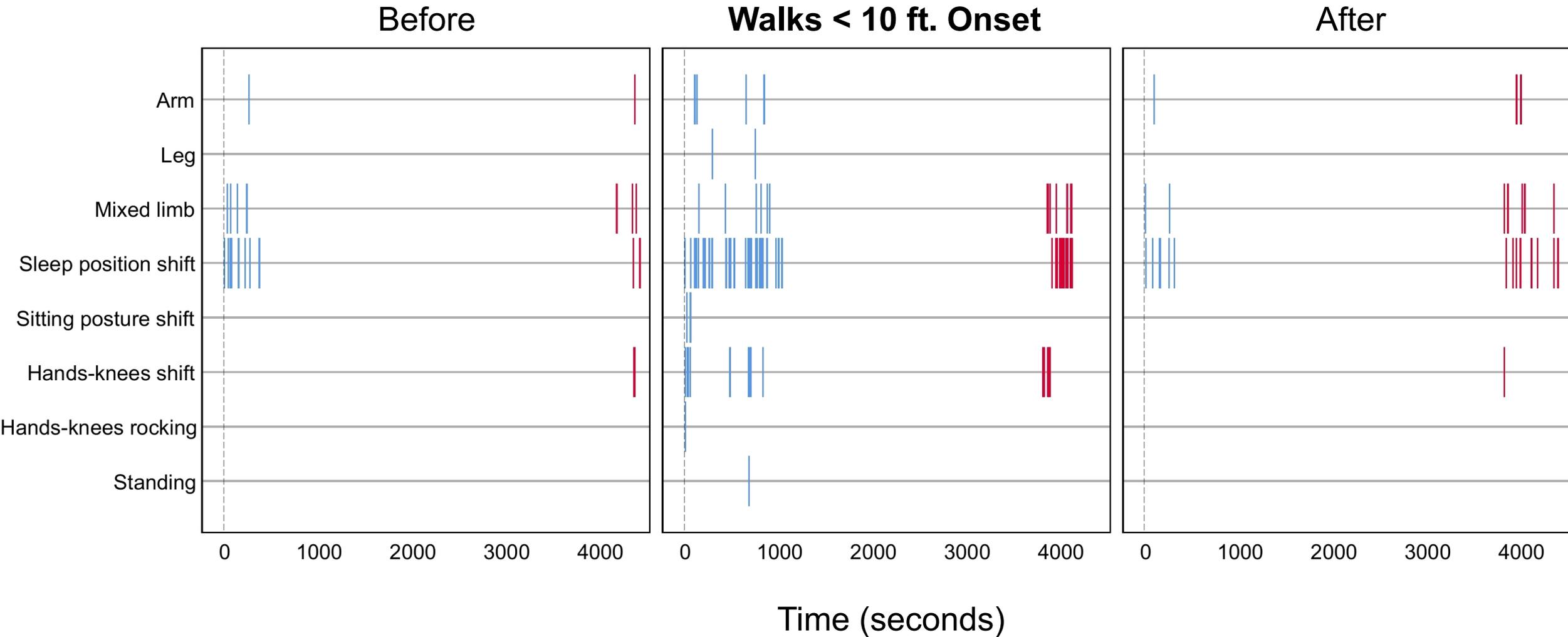
Highest values are highlighted.

Results (2)

	Crawling < 10 ft. (<i>n</i> = 2)			Walking < 10 ft. (<i>n</i> = 1)		
	Before	Of	After	Before	Of	After
Duration of limb movements (<i>SD</i>)	87.38 (53.56)	96.88 (46.49)	53.08 (16.15)	71.00	76.00	51.00
Duration of hands-knees movements (<i>SD</i>)	2.00 (2.83)	21.43 (25.13)	5.50 (7.78)	3.00	19.00	1.00
Crawling (<i>SD</i>)	0.00 (0.00)	2.50 (3.54)	0.00 (0.00)	0.00	0.00	0.00
Standing (<i>SD</i>)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00	1.00	0.00
Sitting (<i>SD</i>)	0.00 (0.00)	14.25 (20.15)	0.00 (0.00)	0.00	4.00	0.00
Sleep position shifts (<i>SD</i>)	15.61 (22.08)	16.56 (12.57)	17.88 (14.32)	5.00	18.00	6.00

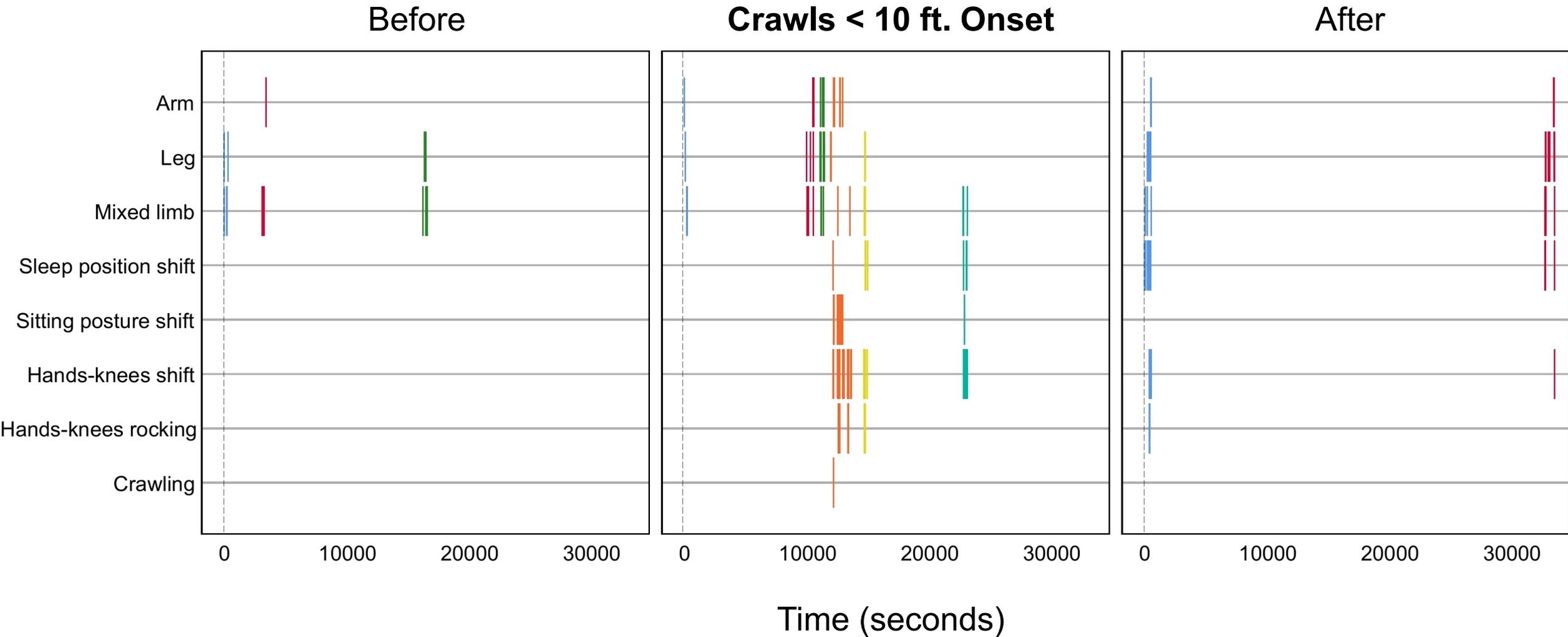
All movement durations are reported in seconds. Movement categories were collapsed for ease of interpretation. Limb movements include arm, leg, mixed arm & leg, and leg lifts. Hands-knees movements include hands-knees propping, rocks on hands-knees, and pushups. Sitting movements include sitting posture shift and rocks while sitting.

Infant #1: 10-month-old



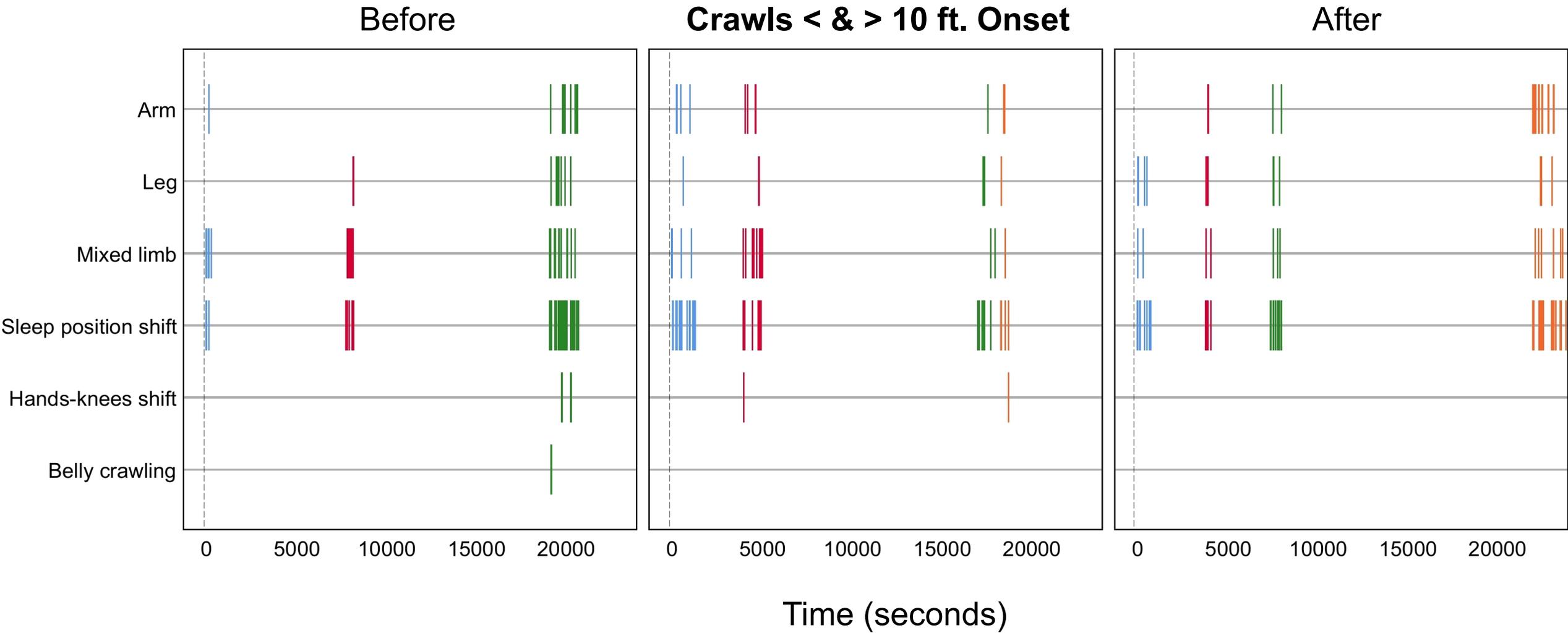
Note. Colors separate wake episodes and each night's origin is standardized at the start of the first wake episode

Infant #2: 8-month-old



Note. Colors separate wake episodes and each night's origin is standardized at the start of the first wake episode

Infant #3: 8-month-old



Note. Colors separate wake episodes and each night's origin is standardized at the start of the first wake episode

Time-Window Sequential Analysis

To explore more deeply the sequential relations between movements and how they occur in time relative to one another, an exploratory time-window sequential analysis (Chorney et al., 2010) was run to test whether learning to crawl influenced how stationary movements (e.g., arm and leg movements) may have triggered the onsets of hands-knees behaviors close in time.

- Hands-knees propping was only likely to occur within a minute of a stationary movement (arm and leg movements) on the nights of and after crawling onset.
- Before infants learned to crawl, they did not show any hands-knees propping 60 seconds after movements made while stationary.
- On the nights of and after crawling onset, the chance of hands-knees propping following stationary arm/leg movements increased from 2% to 5%, respectively.
- Walk onset was unrelated to hands-knees propping within the time-window.

Discussion

- Infants peaked in their total wake minutes, movement type variety, and movements per wake minute on the night of crawling and walking onset
- Durations of almost all movement types increased on the night of milestone onset, whether crawling or walking, indicating that infants are more active during the night when they learn a new locomotor skill
- On the night of crawling onset, infants showed the longest accrued duration of hands-knees type movements, showing that crawlers practice their newly acquired skill
- Hands-knees propping is increasingly likely to follow general movements during wake episodes on and immediately after the night of crawl onset

Future Directions

- Future reports of this research will include data for the walking onsets of the two infants who crawled during the study, allowing for a longitudinal assessment of change in movement types
- While the current study showed that infants' movements peak in duration and amplitude on the night of milestone onset, the range of nights surrounding milestone onset should be expanded to document whether change is gradual or abrupt and whether it is stable after milestone onset
- Non-locomotor milestone onsets such as unsupported sitting and pulling-to-stand should be included in the future

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