Fatigue monitoring in scheduled airline operations

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Background

- Short-haul operations can involve high workload, scheduling variability, and long duty days with multiple takeoffs and landings that may increase vulnerability to operational performance errors (Bourgeois-Bougrine et al. 2003; Powell et al. 2007)
- Acute and chronic sleep loss and circadian disruption are common among commercial airline pilots (Rosekind et al. 2006)
- Data-driven fatigue risk management systems (FRMS) are seen as an important fatigue mitigation tool with science-based scheduling policies and practices, strategies, reporting and monitoring (Gander et al. 2011)
- Neurobehavioral and self-report measures collected in operational settings can provide meaningful information about pilot sleep and performance levels
- Findings can enhance continued evolution of FRMS approach and application

Methods

- 44 short-haul pilots recruited from a single commercial airline
- Continuous data collection for 34 days
- Schedule design included four schedule types:
  - Baseline = low workload "easy" schedule, variable starts
  - Early Starts = scheduled duty before 0900, with multiple segments
  - Midday Starts = scheduled duty after 0900, ending before 2400, with multiple segments
  - Late Finishes = scheduled duty ends after 2400
  - All blocks with 5 duty days, and 3-4 rest days between
  - All pilots scheduled to complete same sequence (e.g., Figure 1)
- Sleep assessed through actigraphy (using Actiware) and daily sleep logs
- Performance assessed with Psychomotor Vigilance Test (PVT)
- Circadian assessment from assay of urinary melatonin following each schedule block (n = 13)
- Analyses included repeated measures ANOVA and mixed-effects regression models

Results

- Majority of pilots were male, under age 40 and <5000 flight hr; 70% FO's; typical commute about 40 min; self-identified sleep need about 8 hr (Table 1)
- Timing of sleep varied by duty block (Figure 2)
- Early starts associated with less sleep relative to baseline ($p < 0.01$); sleep for most late finishes was less relative to sleep prior to first late duty ($p < 0.01$; Figure 3)
- Performance over early, mid and late duty blocks slowed relative to baseline ($p < 0.01$; Figure 4)
- Baseline circadian phase varied by 4+ hr; individual variation in magnitude and direction of phase shifts during duty (Figure 5)

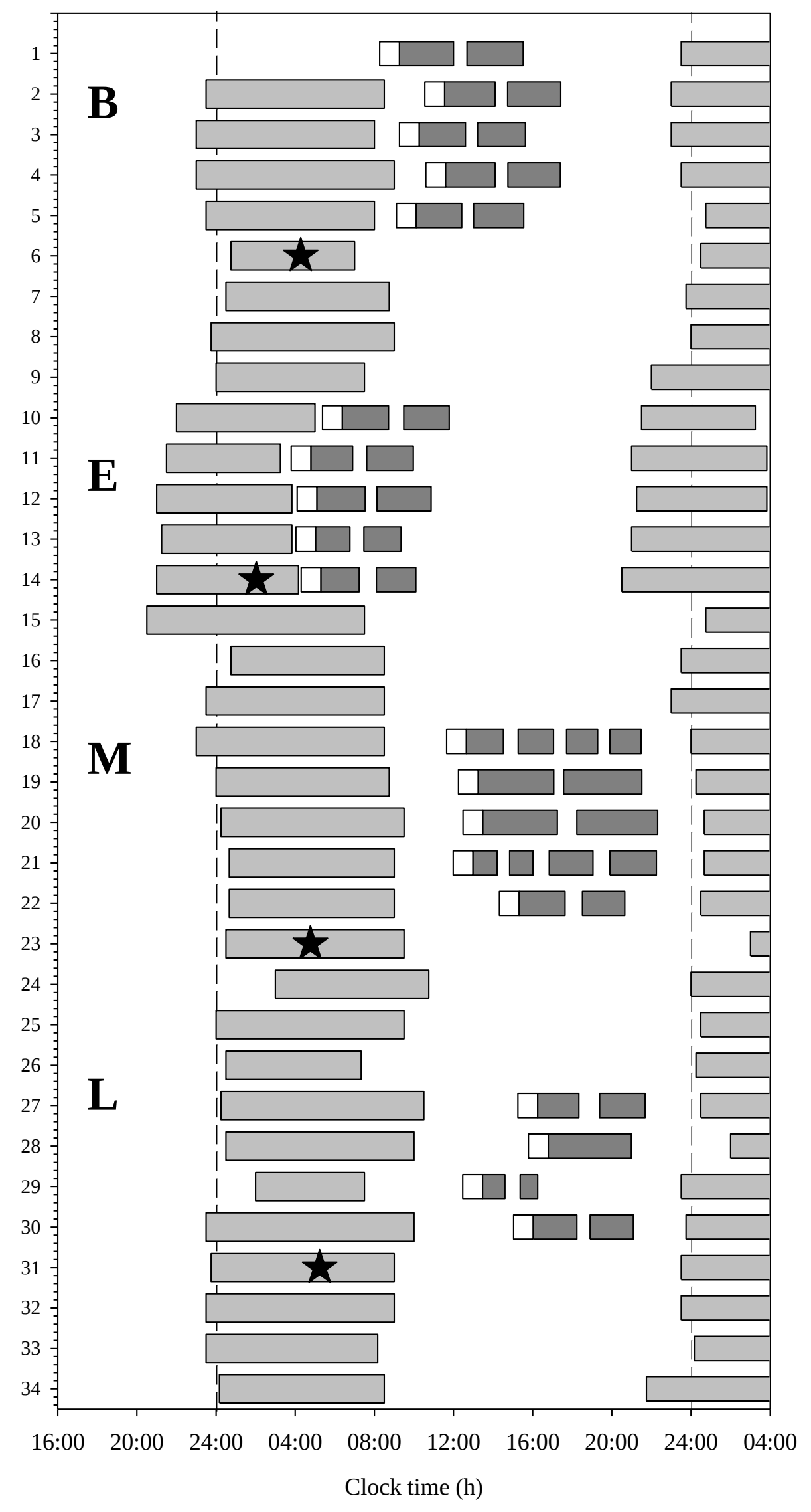

Figure 1. Representative plot of one study participant. Light gray bars represent sleep (double plotted), dark gray bars represent flight time, open bars indicated non-flight duty time (B= baseline, E= early, M= midday, L= late), stars represent circadian acrophase.

Table 1. Participant Characteristics (m, range)

N	44
Age	30.8 (21-50)
BMI (kg/m^2)	24.2 (20.4-32.7)
Self-report sleep need (h)	7.9 (7.0-9.5)
	n (%)
Female	4 (9)
Commercial Flight Hours	
<1000	6 (14)
1000-4999	24 (55)
5000-7999	11 (25)
8000+	3 (7)
Marital Status	
Single	30 (68)
Married	14 (32)
Shared housing	21 (49)

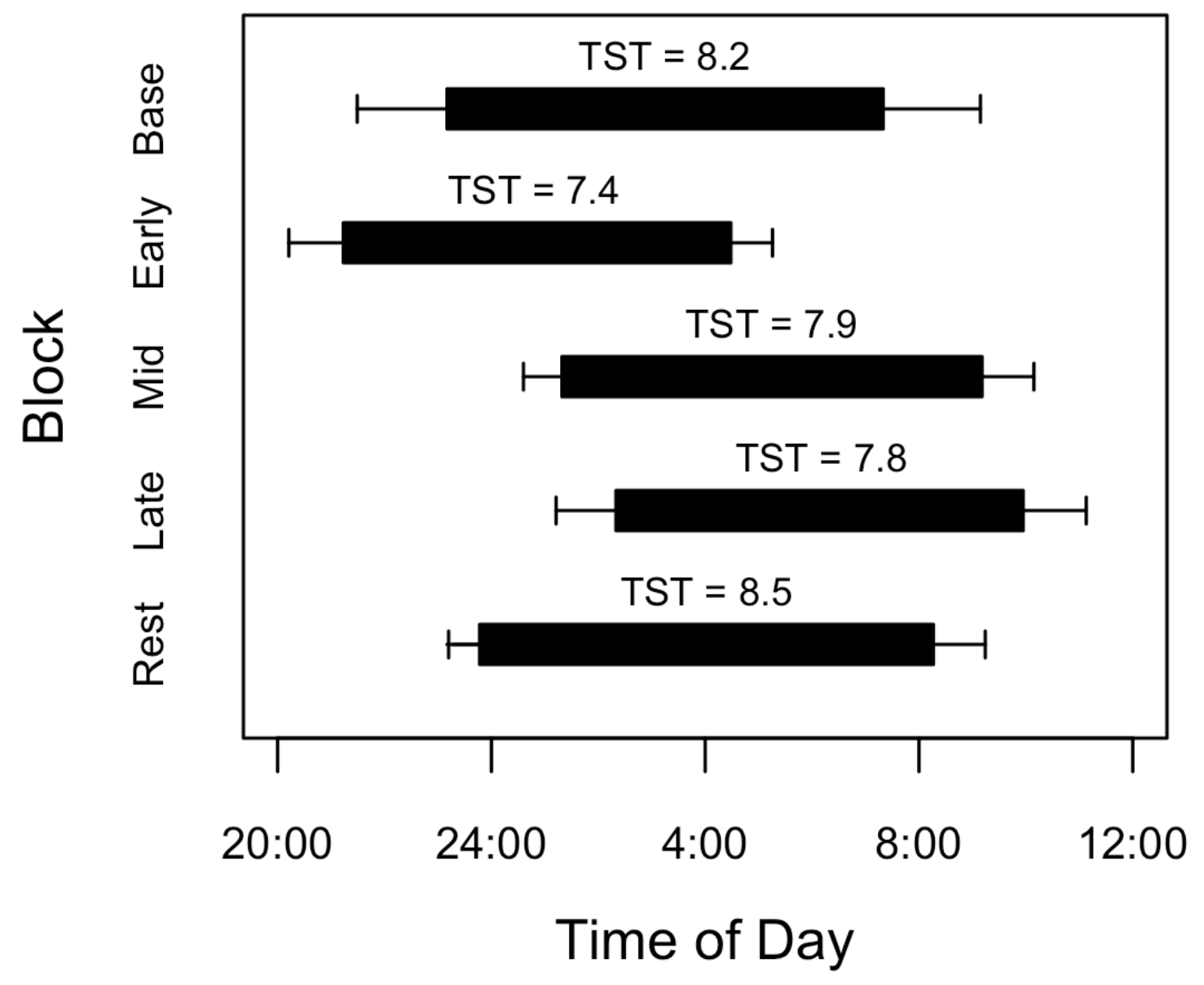

Figure 2. Self-reported bed and wake times (+/- SD); TST= mean total sleep time

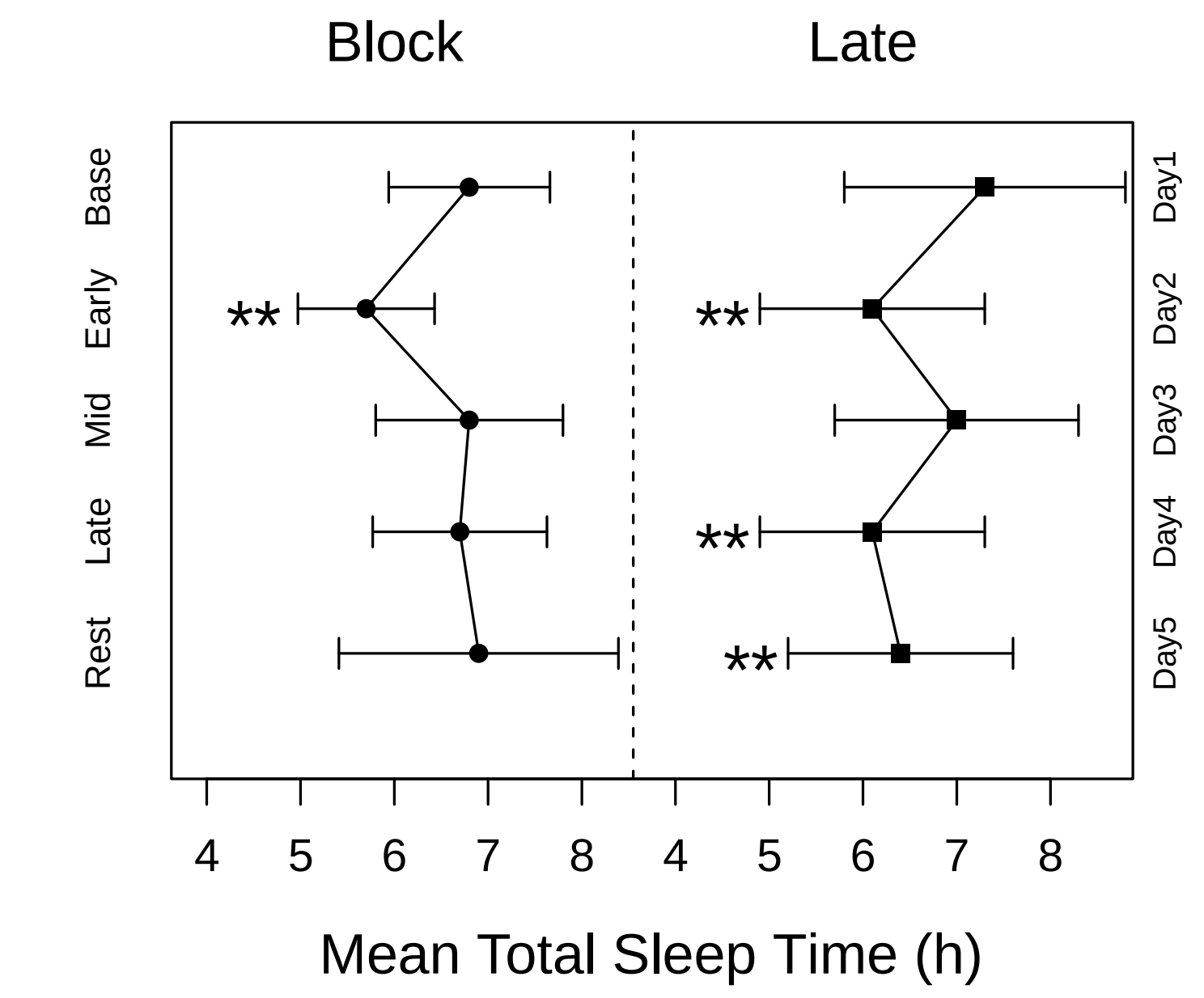

Figure 3. Mean sleep duration differed by block and by about an hour across days on late schedule. (** p<0.01)

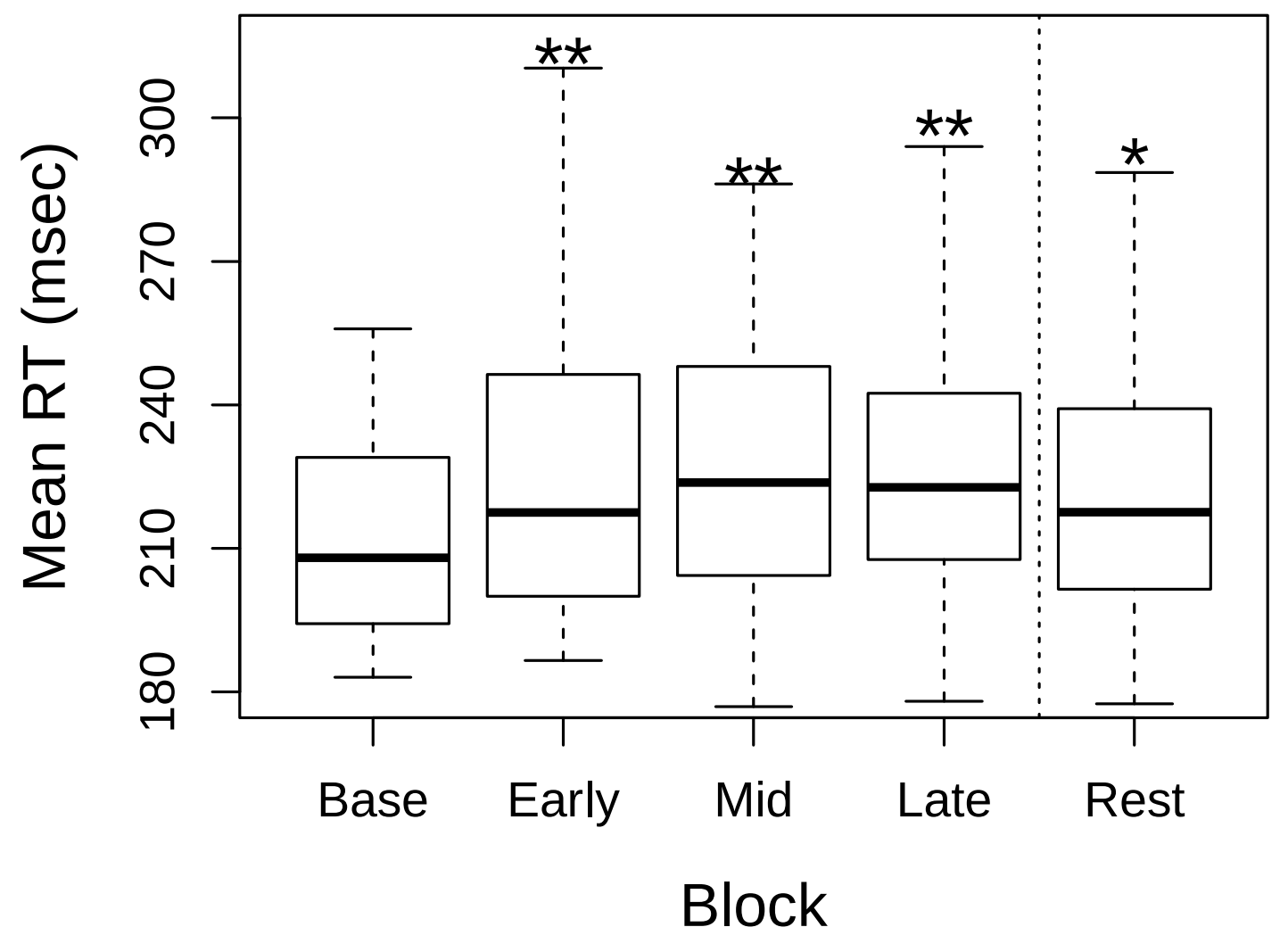

Figure 4. Mean reaction time (RT) as measured by PVT differed by duty block, and showed more variation during early duty. (** p<0.01; *p<0.05)

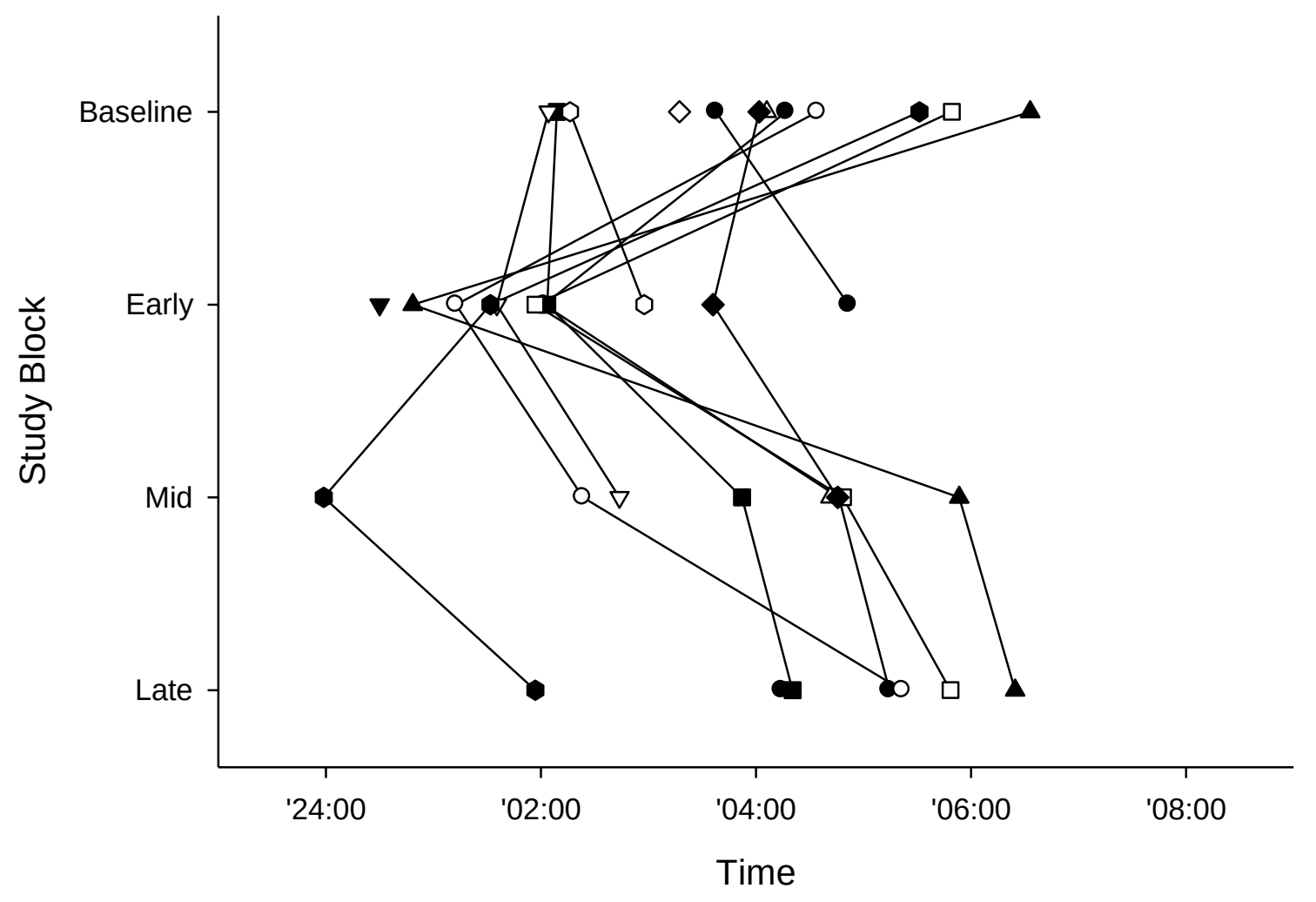

Figure 5. Cosinor-derived aMT6s acrophase by schedule for each of the 13 participants who completed the urine collection.

Conclusions

- 44 pilots successfully gathered sleep and performance measures during airline operations over a month period
- Pilot sleep duration was affected by scheduling and circadian factors with reduced sleep during early duties and variable sleep during late duties
- Inter-individual variations in measures of circadian phase
- FRMS pilot education and training should emphasize individual variations, personal awareness and effective mitigation strategies

References

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