How Do Environmental Factors Affect Sleep Patterns in the Adolescent BaYaka Population?

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1 Introduction

Research Objective: Examine how different environmental factors impact the BaYaka children's sleep, and compare these findings to previous studies on BaYaka adult sleep.

Traditional sleep studies often suggest eight hours as ideal, but they lack a cross-cultural perspective, especially in marginalized and non-industrial societies. Factors like social environment, light exposure, exercise, temperature, and diet influence sleep-wake regulation. While polysomnography (PSG) studies simulating the environment in labs offer insights, they cannot fully replicate real socio-cultural environments.

Environmental factors affecting sleep are well-studied in post-industrial societies, but there's a gap in research on BaYaka adolescents.

Based on previous studies and a comprehensive summary by Samson (2020), we hypothesize the following relationships between meteorological variables and sleep duration:

Predictor	Hypothesis
Wind speed	Higher wind speeds result in shorter sleep durations (refer to ambient noise in Samson's (2020) paper).
Heat index	An increased heat index results in longer sleep durations.
Cloud cover	Increased cloud cover increases sleep duration (see Minor et al., 2022).
Precipitation	Increased precipitation will decrease sleep duration.
Location	Being located in the forest rather than the village will increase sleep duration (refer to ambient noise in Samson's (2020) paper).
Moon phase	As moon phases approach the new moon, sleep duration increases (see findings of Samson et al., 2018).
Dew point	An increased dew point will decrease sleep duration.

3 Results

Table 1: Overall descriptive sleep quotas (n = 57) and nap/TTST quotas (n = 40) of the BaYaka from actigraphic analysis.

Sleep onset	21:05 (1:07)
Sleep end	5:59 (0:26)
Time in bed (h)	8.72 (0.96)
Total sleep time (h)	6.86 (0.97)
Wake after sleep onset (h)	1.59 (0.46)
Sleep efficiency (%)	78.81 (5.44)
Sleep fragmentation	33.31 (9.16)
Twenty-four hour total sleep time (h)	7.83 (1.78)
Nap period duration (h)	0.85 (1.01)

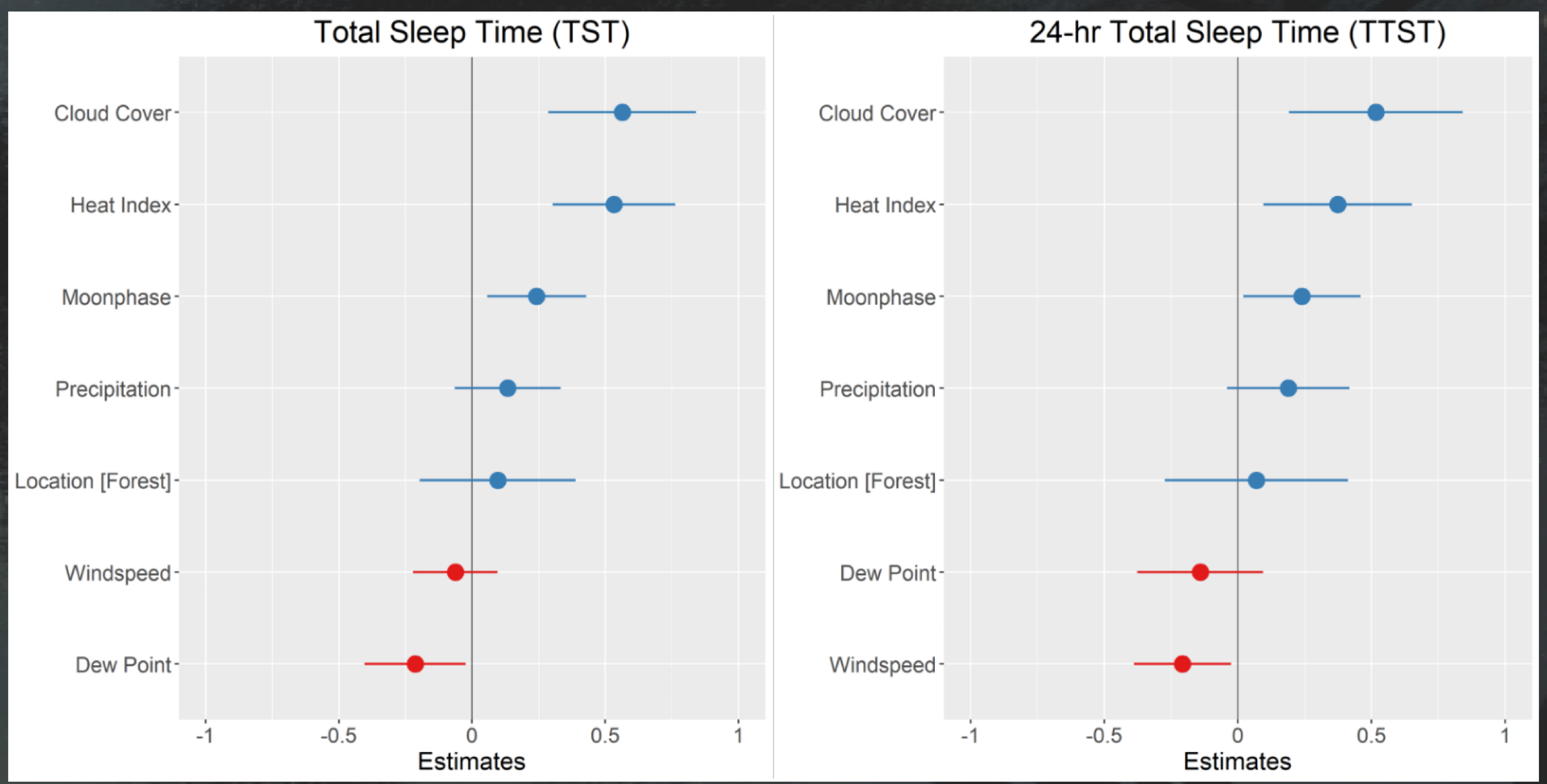


Figure 1: Fixed-effects plot showing how the predictors impact both TST (n = 57) and TTST (n = 40) on adolescent sleep. The reference variable for moonphase is set as the new moon. Predictors that have a positive effect on both response variables are represented by blue, while negative effect predictors are denoted by red. The lines represent the 95% confidence intervals.

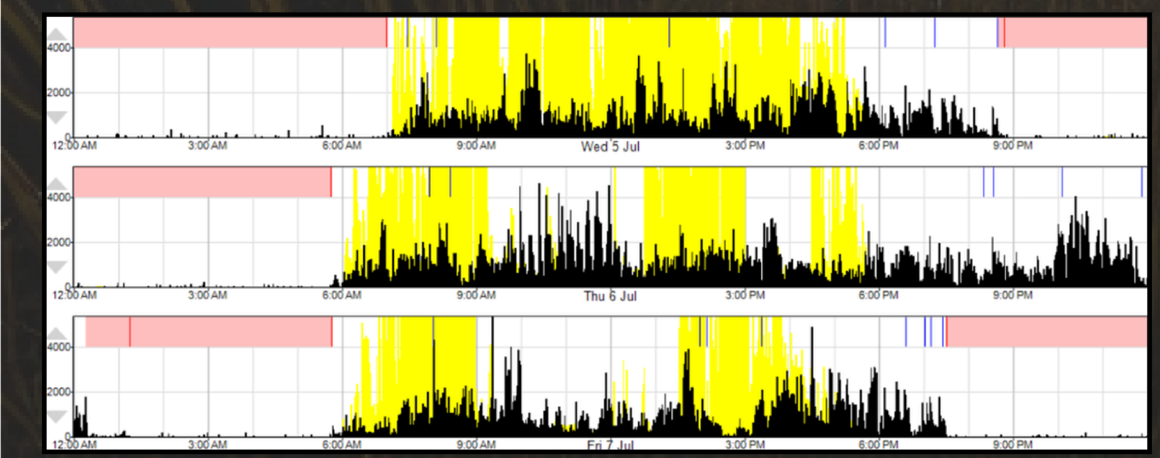
Key Findings:
- Cloud cover, heat index, and moon phase are positive predictors for TST and TTST
- Location and precipitation are not significant predictors for TST or TTST
- Dew point is a negative predictor for TST, but not significant for TTST
- Wind speed is a negative predictor for TTST, but not significant for TST

2 Methodology

The methodology for this study is adapted from Killius et al. (2021). We used MotionWatch 8 devices to collect actigraphy data during the summer of 2023. MotionWatches record light and activity data, which are used to determine sleep-wake periods. We report a final sample size of 57 for most sleep variables, 40 for 24-hour total sleep time and nap duration, and 67 for daytime activity analysis.

A total of 224 nights were analyzed (village = 90 nights, forest = 134 nights, range = 3-6 days per participant, and for TTST, a subset of 167 nights were included.

Below is an example of a participant's data:



Forecast data was obtained from WorldWeatherOnline using the exact coordinates of the village (latitude 17.50, longitude 2.48). Hourly data from 9 PM to 6 AM were averaged to compare the variables mentioned in the hypothesis to sleep quotas.

We created a linear mixed-effects model using the environmental data as our predictors. The equation is:

$$\textit{Sleep quota} \sim \textit{wind speed} + \textit{heat index} + \textit{precipitation} + \textit{cloud cover} + \textit{location} + \textit{dew point} + \cos(\textit{moonphase}) + (1|\textit{subject})$$

4 Discussion

Descriptive Sleep Quotas:

Our findings suggest that BaYaka children have lower sleep duration, higher sleep fragmentation, and lower sleep efficiency than children in post-industrial societies. In comparison to the adult BaYaka population, sleep duration is higher, fragmentation is significantly lower, and sleep efficiency is higher as well, suggesting that adolescents obtain better quality sleep.

Environmental Predictors:

Heat index will tend to increase as cloud cover increases, a phenomenon that occurs during the nighttime as reported by Rokonuzzaman and colleagues. This also correlates with the findings of Samson (2017a), where temperature is a positive predictor of sleep duration, thus supporting our findings. In addition, the moon phase findings are in line with what Samson and colleagues (2018) found in the Hadza population.

We found that precipitation and location are not significant predictors of sleep duration. These results do not support H1. The results for precipitation can likely be explained by the lack of variation in precipitation over the study period. As for location, similar results were observed in Killius and colleagues' findings.

Lastly, we found that wind speed was a negative predictor, as originally hypothesized. This may be explained by Samson's (2015) sleep intensity hypothesis. While the concept applies to all humans, it is most applicable to individuals with more exposure to predation risks, which would be the case for BaYaka children.

5 Conclusion

Our study's results indicate that there are a handful of environmental factors at play influencing sleep in the adolescent BaYaka population. We found evidence for five predictors, with three predictors overlapping between TST and TTST. In the future, we would like to improve our model to examine how the predictors impact sleep efficiency and sleep fragmentation.

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