Behavioral periodicity detection from 24h waveform wrist accelerometry

Matthew P. Buman[1], Feiyan Hu[2], Eamonn Newman[2], Alan F. Smeaton[2], Dana R. Epstein[3]

[1]Arizona State University; [2]Dublin City University; [3]Phoenix Veterans Affairs Healthcare System

PURPOSE

Develop a framework for identifying meaningful periodicities (i.e., repeating patterns) and the strength of these periodicities from 24h waveform wrist accelerometry.

INTRODUCTION

- Sleep, sedentary behavior, and more active behaviors each impact health independently; yet their combined (joint) impact is not well understood.
- Periodicities (i.e., repeating patterns) can be observed in many human behaviors - most notably circadian patterns.
- The strength of these periodicities may capture untapped patterns that incorporate sleep, sedentary, and more active behaviors into a single metric indicative of better health.
- Wearable sensors can be used to characterize daily, weekly, and annual patterns of sleep and physical activity that extend beyond traditional methods (e.g. accelerometry thresholds, sleep/wake rhythms).

METHODS

Participants

- N=26 adults (22 men, 4 women; 49±9 [range: 35-65] years of age; 73% Caucasian; BMI = 35±8 kg/m^2).
- Participants were recruited for participation in a smartphone-based behavioral intervention targeting changes in sleep, sedentary, and more active behaviors.

Procedures

- GENEactiv accelerometer (ActivInsights, Kimbolton, UK) data were sampled on the wrist continuously for 28-72 consecutive days at 40Hz.
- Interim sensors were sent to participants by mail to encourage continuous wear.

Data analysis

- Data were summarized to 60sec epochs using the gravity-subtracted sum of vector magnitudes.
- For each participant, power spectral densities for a continuous spectrum of frequencies from hourly to weekly, known as periodograms, were used to determine regular cycles emergent from the data.
- Circular autocorrelations were calculated for time-lagged windows (3 days; based upon strongest frequency) to identify the changes over time in the strength of the periodicities.

RESULTS

- Similar patterns in the data emerged across the sample of 26 participants.
- Data from an exemplar in Figure 1 is used to illustrate the findings.
- Panel A shows descriptive acceleration data across the observed period.
- Panel B demonstrates the only notable periodicity is at 24 hours (i.e., a circadian rhythm) with no within-day or weekly patterns observed.
- Panel C demonstrates that the 24h periodicity held consistently over the majority of 3-day windows with small breaks at the beginning and end of the monitoring period.
- Panel D shows that the 24h periodicity was strongest following day 10 and then again around day 57, with more consistent periodicities during the rest of the monitoring period.

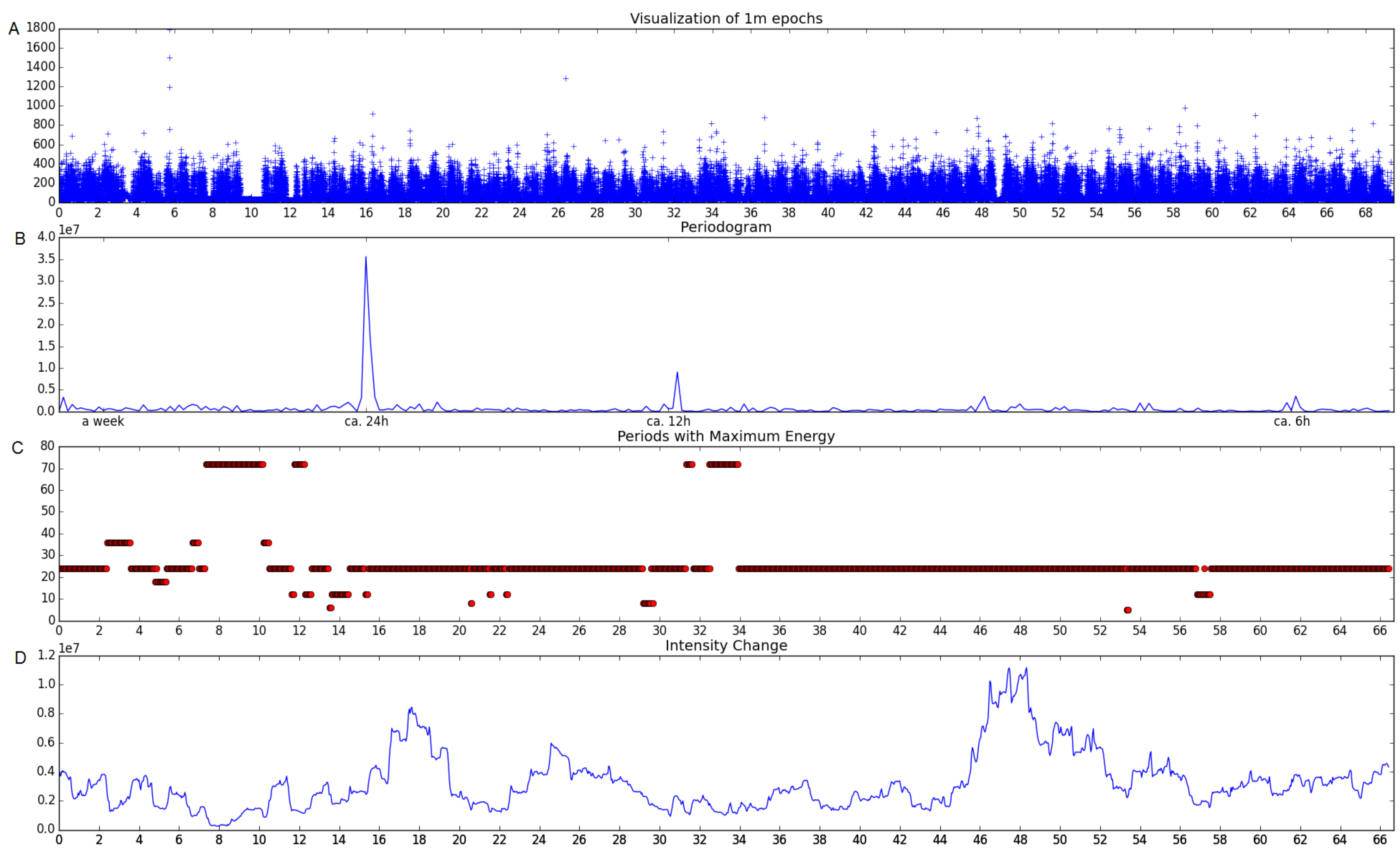

Figure 1. Exemplar data of 24h behavior periodicities over 70 consecutive days of wrist-worn accelerometry.

CONCLUSION

- This analytical framework demonstrates a new method for characterizing behavioral patterns that encapsulate behaviors across the 24h spectrum longitudinally.
- Our results indicate a pattern that resembles natural circadian rhythms; however, this framework is flexible to identify additional periodicities that may emerge and characterizing the strength of these patters.
- Future directions of this work include (a) examining longer-term data to see whether seasonal or annual patterns may arise; (b) determining whether the strength of the periodicities are related to health outcomes of interest (e.g., cardiometabolic health, longevity); and (c) exploring whether periodicity strength is responsive to change via behavioral sleep or physical activity interventions.

This work was funded in part by the Virginia G. Piper Charitable Trust, the ASU/DCU Catalyst Fund, Science Foundation Ireland under grant 12/RC/2289 and by the European Community 7th Framework Programme (FP7/2007- 2013) under grant agreement 288199 (Dem@Care). For more information, contact Matthew Buman at matthew.buman@asu.edu; Presented at the International Conference on Ambulatory Monitoring of Physical Activity and Movement (ICAMPAM), Limerick, Ireland, June 10-12, 2015.

School of Nutrition & Health Promotion
ARIZONA STATE UNIVERSITY

SEVENTH FRAMEWORK PROGRAMME

Insight

DCU