On the influence of the menstrual cycle on the performance of female cyclists

A functional multilevel modelling approach

S. Golovkine · T. Chassard · A. Meigné · E. Brunet · J.-F. Toussaint · J. Antero

National Sport and Human Performance Conference
September 29th, 2023

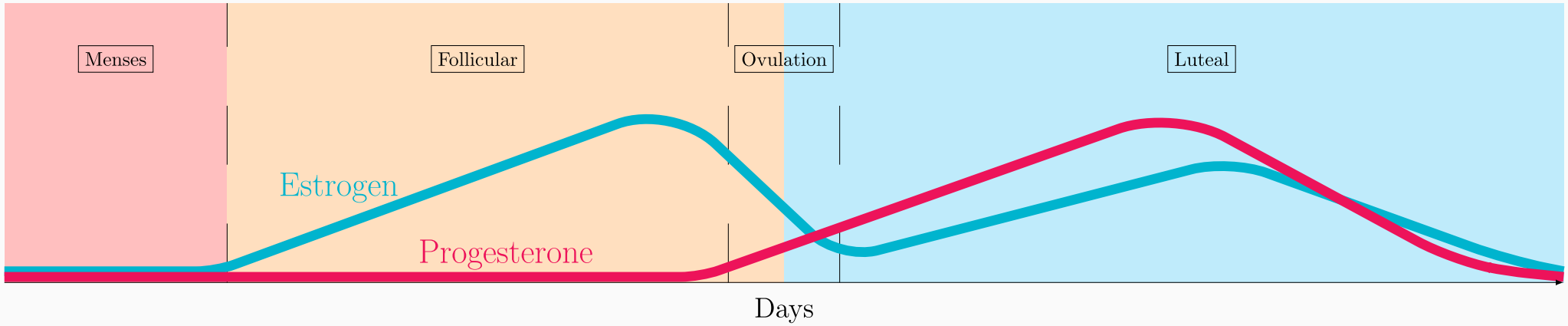
Cycling

Road

Track

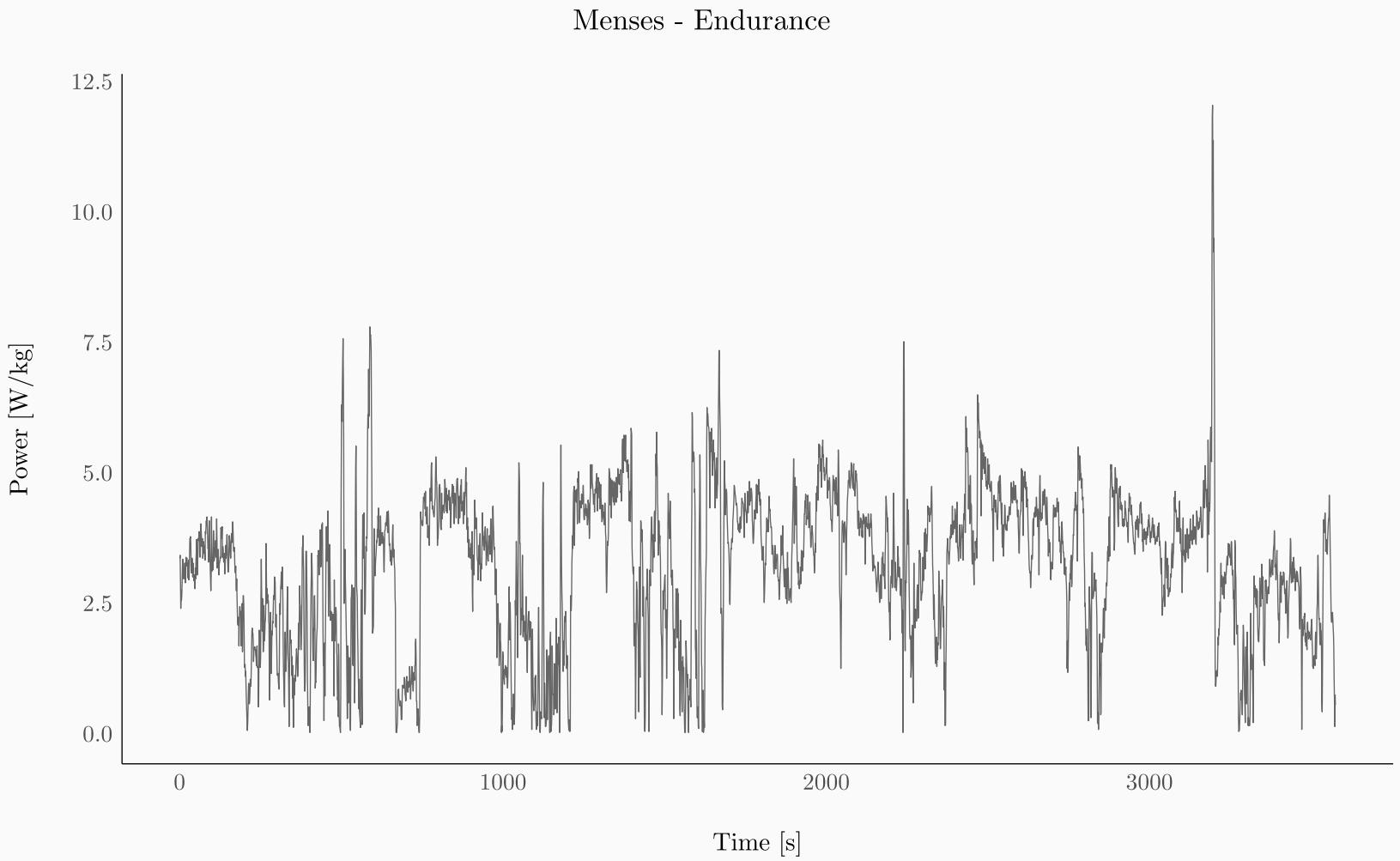
Cross-country

Hormonal fluctuations



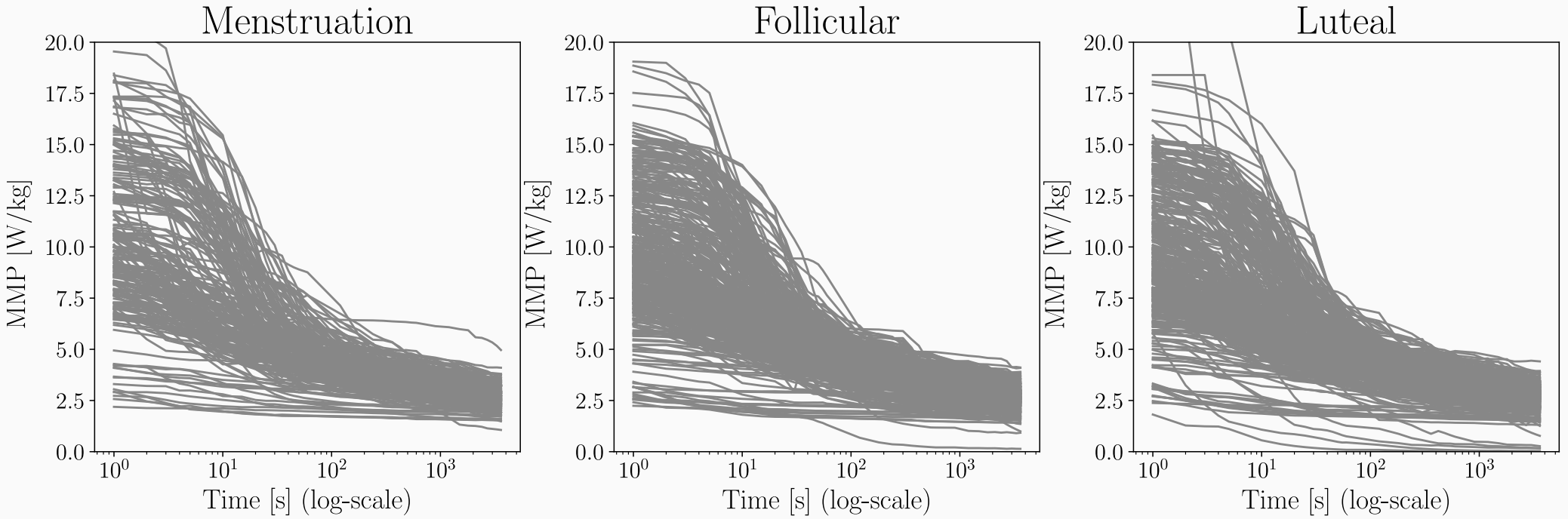
Schema of a menstrual cycle (adapted from McNulty et al., 2020).

Power Data



Example of data recorded from training.

Mean Maximal Power Curves



MMP per phase.

Model

- MMP curves consist of random realizations from a stochastic process $X = \{X(t) : t \in [1, T]\}$ with continuous trajectories.

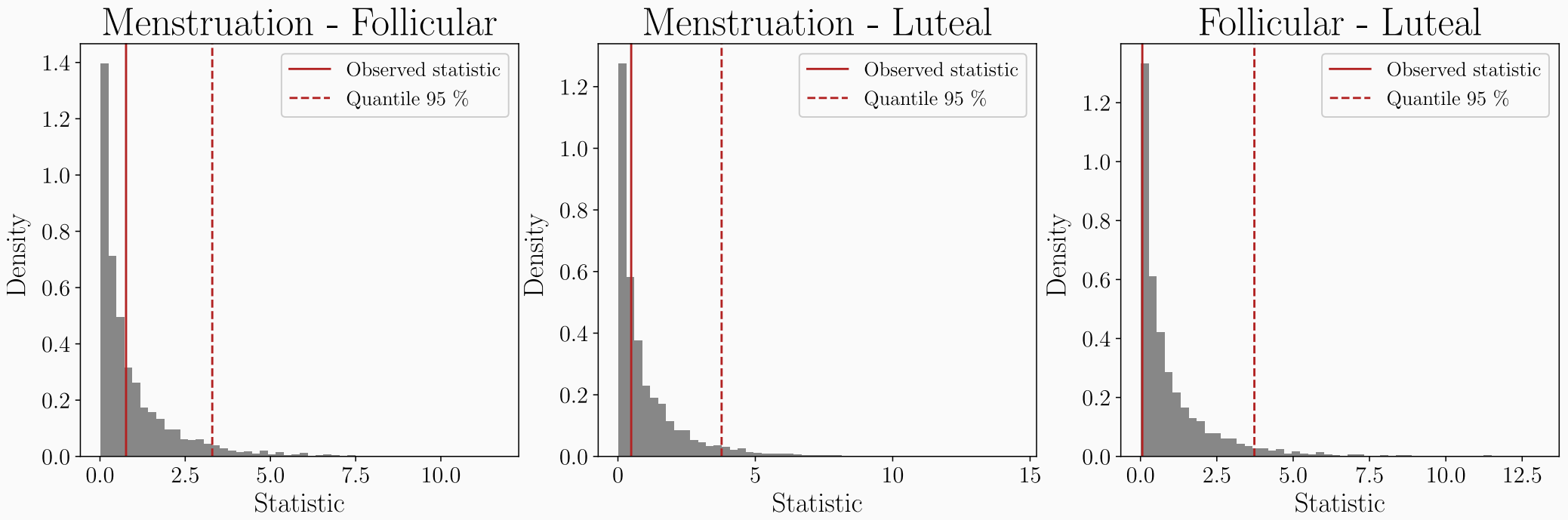
- We consider the following model

$$X_{jklmn}(t) = \mu_k(t) + B_{jk}(t) + C_{lk}(t) + D_{mk}(t) + E_{jklmn}(t)$$

  where

  - $X_{jklmn}(t)$: MMP output for a particular observation.
  - $\mu_k(t)$: fixed effect for the phase of the menstrual cycle.
  - $B_{jk}(t)$: phase-specific functional random intercept accounting for athlete.
  - $C_{lk}(t)$: phase-specific functional random intercept accounting for training intensity.
  - $D_{mk}(t)$: phase-specific functional random intercept accounting for bike type.
  - $E_{ijl}(t)$: smooth error term accounting for observation-specific variability.

Mean comparison



Variance decomposition

Full variance decomposition using a functional random intercept for phase with variance explained of $99.999\ \%$.

Variability source	**Variance explained (in $\%$)**
Phase	2.41×10^{-3}
Athlete	22.0
RPE	11.5
Bike type	16.6
Observation	49.8
Error variance	6.60×10^{-11}

Takeaway ideas

- Power output data exhibits the variable nature of performance in women's professional cycling.
- We have not proven that there is no variation between phases, we have failed to find evidence of variation between phases.
- The athletes are likely to achieve their peak performance in each phase.
- These results may be helpful for coaches who use these curves for training planning or the comprehension of their athletes.

Thank you for your attention!

References

Cederbaum, J. (2017). "Functional linear mixed models for complex correlation structures and general sampling grids". Text.PhDThesis.

McNulty, K. L., K. J. Elliott-Sale, E. Dolan, et al. (2020). "The Effects of Menstrual Cycle Phase on Exercise Performance in Eumenorrheic Women: A Systematic Review and Meta-Analysis". In: Sports Medicine 50.10, pp. 1813–1827. ISSN: 1179-2035. DOI: 10.1007/s40279-020-01319-3.

Soumpasis, I., B. Grace, and S. Johnson (2020). "Real-Life Insights on Menstrual Cycles and Ovulation Using Big Data". In: Human Reproduction Open 2020.2. DOI: 10.1093/hropen/hoaa011. pmid: pmid. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7164578/ (visited on Jul. 18, 2023).