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Abstract

On the influence of the menstrual cycle on the performance of female cyclists: a functional multilevel modelling approach

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Introduction
Menstrual cycles affect women's health and wellness. Female sex hormones, and especially, oestradiol and progesterone, fluctuate along the menstrual cycle. These hormones affect multiple parameters on women ranging from adverse symptoms, such as fatigue or sleep disturbance along menstrual cycle phases (Pierson et al., 2021), to many beneficial cardiovascular, muscular, and metabolic parameters (Meignié et al., 2021). Performance-based research in women sport science is still scarce regarding the influence of menstrual cycle phases (Meignié et al, 2021). Cycling is interesting to analyse the influence of hormonal fluctuation onto female performance. Performance can be measured using Mean Maximal Power (MMP) curve.

Method
Power output data were recorded at 1Hz by personal power meter. An MMP curve was derived from every individual training. Eight high-level female cyclists, with natural cycles, volunteered to participate in the study. We asked the cyclists to inform us of the start and end of their period, and we estimated the day of ovulation for each cycle. Their menstrual cycles were divided into three phases: the menstruation, the follicular, and the luteal phase. A functional linear mixed model has been proposed to assess whether performance differs between phases of the menstrual cycle and how performance varies over the cycle based on the athletes, training intensities and types of the bike.

Results
The test statistic computed on the observed data is smaller than the 95%-quantile of the distribution of the test statistics computed on the bootstrap samples for all phases comparison. There is no evidence of a difference between the phases considering their mean MMP curves. The decomposition of the variance highlights the importance of accounting for the different sources of variability as most of the overall variability is induced by the different observations (49.8%). The second most important source of variability is induced by the athletes (22%). It appears that the different phases induce zero variation of power output.

Conclusions
We found no evidence of a difference in the mean MMP curves for the different phases. The variability in the data is not influenced by the different phases and is mostly due to the difference between the athletes and the randomness of the repeated observations. We have however not proven that there is no variation between phases, we have failed to find evidence of variation between phases. The athletes are thus likely to achieve their peak performance in each phase.

Practical Applications
These results may be helpful for coaches who use these curves for training planning or the comprehension of their athletes. It may also help the athletes to refine team strategies and enhance in-race decision making.

References
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Soumpasis, I. et al. (2020). *Human Reproduction Open*.