Recovery through the menstrual cycle: Learnings from a large dataset of biometrics and behavior

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Summary

Understanding how the menstrual cycle affects performance and recovery are the topics ranked of highest importance in a survey of 40 female Olympic athletes [1]. We investigated whether phase of the menstrual cycle affects biometrics associated with recovery and overtraining by analyzing cardiac metrics, sleep duration, and workout intensity from 2,596 naturally menstruating users of a wrist-worn device. We found that menstrual cycle phase, workout intensity, and sleep interacted with heart rate variability (HRV) ($p < 0.01$). HRV during the menstrual and premenstrual phases was most affected by sleep (5% reduction in HRV for 5 vs. 8 hours of sleep) and workout intensities (2% reduction for a week of intense vs. moderate exercise). These results support anecdotal reports and smaller studies, highlighting the interplay of recovery dynamics and hormonal fluctuations.

Introduction

Adverse menstrual cycle symptoms in athletes are most often observed during the premenstrual and menstrual phases [2]. Women also report working out at lower intensities during the premenstrual phase, potentially because hormones in the premenstrual phase induce slightly elevated heart rate, ventilation, and temperature [3]. We explored the relationship between workout intensity and recovery over the menstrual cycle using HRV, a key recovery metric. HRV has been shown to relate to the state of the sympathetic and parasympathetic nervous systems, and lower HRV has been associated with overtraining [4]. We hypothesized that HRV would be lowest in the premenstrual phase and that poor sleep and intense workouts would have differing effects on HRV across the menstrual cycle.

Methods

We curated a dataset of nightly HRV measurements from 2,596 menstruating users who consistently wore a wristband device for 2 years (≥75% of time) and did not use hormonal birth control. The device recorded sleep duration, HRV (with the root mean squares of successive differences method), and time spent in heart rate (HR) zones during workouts. Users reported age, height, and weight, which we used to calculate body mass index. Users also reported over 45,000 menstrual cycle onsets, which we used to define menstrual cycle phases: menstrual phase is the week of menses, postmenstrual phase is the following week, and premenstrual phase is the week prior to menses onset. For each phase of each menstrual cycle in the dataset, we computed the average sleep duration and workout intensity (weighted sum of minutes spent in HR zones [5]). We built a linear model to predict HRV offset (change from a user's mean), using menstrual cycle phase, sleep duration, and workout intensity while controlling for resting HR offset, age, and body mass index.

Results and Discussion

HRV was modulated by cycle phase, with the premenstrual phase exhibiting the lowest HRV values across users ($p<0.001$). Sleep and workout intensity also affected HRV, with differences between menstrual phases ($p<0.001$). For example, assuming a fixed workout intensity equivalent to 60 minutes in HR zone 1 (50-60% max HR) per day, lower sleep durations (5 hours vs. 8 hours) were associated with lower HRV values in all phases ($p<0.001$). The premenstrual and menstrual phases exhibited the largest drops of 3.3 ms (5% of the mean HRV). For a fixed sleep duration of 8 hours, greater daily workout intensities (e.g., 60 mins in HR zone 4 at 80-90% max HR vs. 60 mins in zone 1) were associated with lower HRV values for menstrual (1.4 ms), premenstrual (1 ms), and postmenstrual (0.7 ms) phases ($p<0.01$).

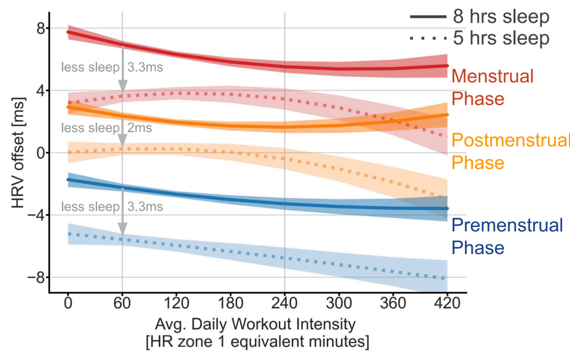

Figure 1: Predicted HRV offset (change from a user's mean HRV) across cycle phases (red, orange, blue lines), sleep (solid vs. dashed lines), and workout intensity (x-axis). Model $R^2 = 0.57$. Error bands represent the 95% confidence intervals.

Conclusions

Users' HRV responses to workout and sleep varied throughout the menstrual cycle. The largest drops in HRV were associated with less sleep and intense workouts during the premenstrual and menstrual phases.

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References

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