

Purpose

A limiting factor of aerobic power is the oxygen supply to the muscles during high-intensity exercise (1). The demarcation between heavy and severe exercise domains is represented by critical power (CP). At this point, the production of H+ ions exceeds buffering capacity through ventilation, and acidosis ensues. Therefore, CP represents the highest work rate that can be achieved for extended durations (20-30 minutes). We hypothesize that muscle oxygen kinetics should trend toward an asymptotic threshold at CP as pulmonary oxygen uptake meets the demand for muscle oxygenation (SmO2).

Methods

Eleven adult subjects with moderate rowing experience completed CP testing using an indoor rower, including six females (age=32.8±8.5, mass=76.83±16.5 kg, body fat=28.5±6.8%) and five males (age=35.2±4.2, mass=83.3±13.9 kg, body fat=20.8±5.3%). Subjects completed a 3-minute all-out test (3MT) to determine CP (2). Subjects warmed up for 3 minutes at a 100W pace, then rowed at an all-out pace for 3 minutes without feedback on the test duration or intensity (to avoid pacing effects), followed by a 5-minute cool-down. Anaerobic capacity is exhausted through the first 150 seconds of the 3MT. Therefore, CP can be measured by averaging the work rate (i.e., watts) of the last 30 seconds of the test. SmO2 was recorded via a sensor placed on the vastus lateralis, midway between the greater trochanter and the lateral epicondyle. An exploratory approach was taken for this study. Descriptive statistics and piecewise regression were used for statistical analysis.

Results

SmO2 values of 72.5±10.9% and 69.8±12.7% were observed during the warm-up and cool-down, respectively. Segment analysis of the SmO2 data during the 3MT revealed three distinct phases of SmO2 activity. Phase 1 demonstrates a rapid drop in SmO2 ($\Delta M = -20.3 \pm 16.4\%$; $b = -0.83 \pm 0.8$) for a duration of 59.7±21.2s. Phase 2 indicated a plateauing effect of SmO2 ($\Delta M = -4.4 \pm 7.9\%$; $b = -0.05 \pm 0.1$) with an average duration of 64.4±23.0s. Phase 3 showed a SmO2 resaturation ($\Delta M = 1.87 \pm 8.8\%$; $b = 0.04 \pm 0.15$) for a duration of 65.21±29.3s. Phase 3 was not observed for subject 6 as no change in the SmO2 slope was determined beyond the 2nd phase. Overall, the mean range of SmO2 during the 3MT was 34.8±21.3%. There was a strong negative correlation between body fat and SmO2 range ($r(9) = -0.69$, 95% CI[-0.91, -0.16], $p < 0.05$).

Conclusion

SmO2 aligns with expected oxygen kinetics during a 3MT on an indoor rower. Moreover, a stabilized SmO2 at the end of the 3MT may indicate that the athlete has reached CP. However, due to the limitations of the SmO2 sensor, subjects with higher subcutaneous fat may show less SmO2 activity.

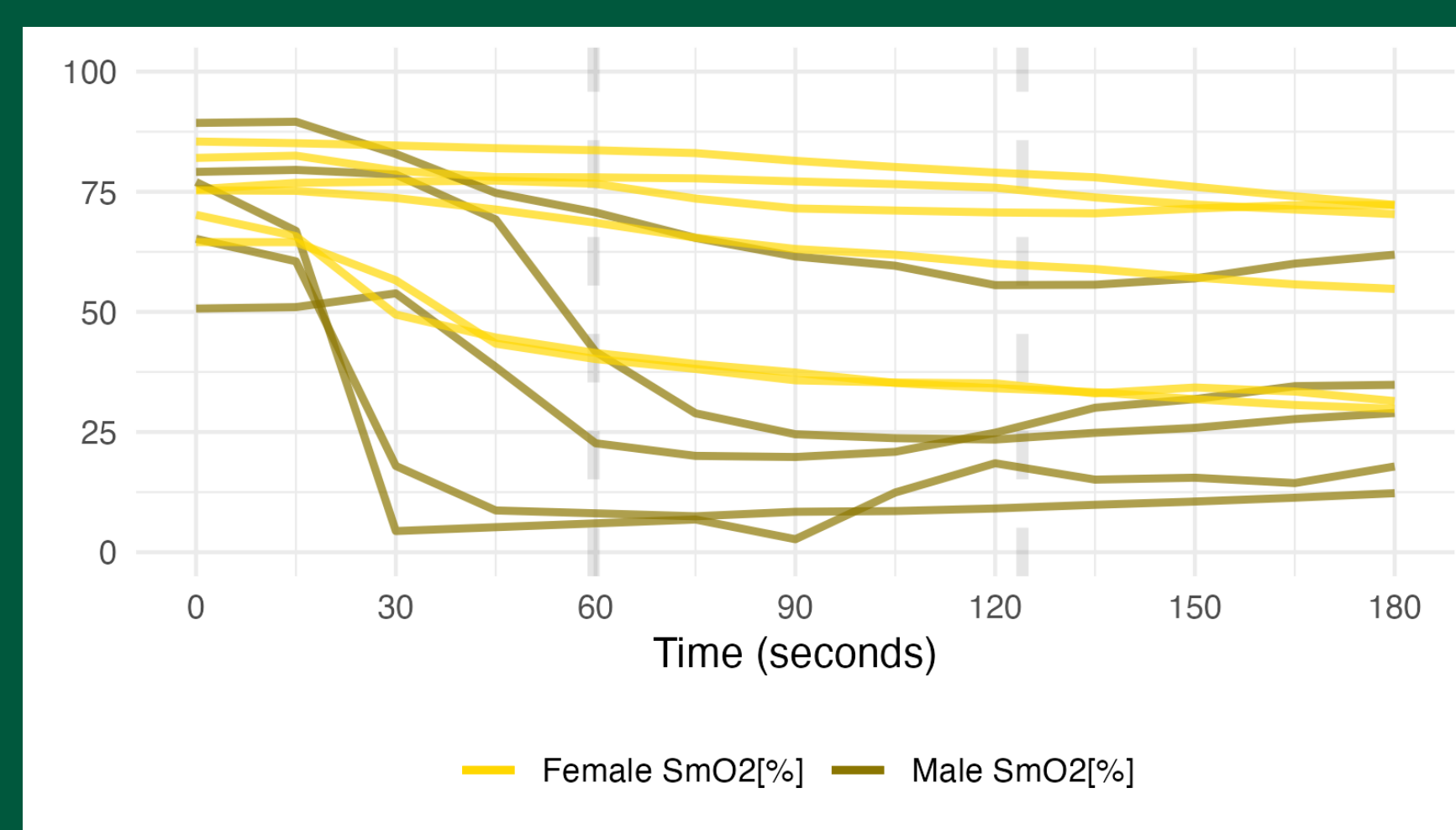
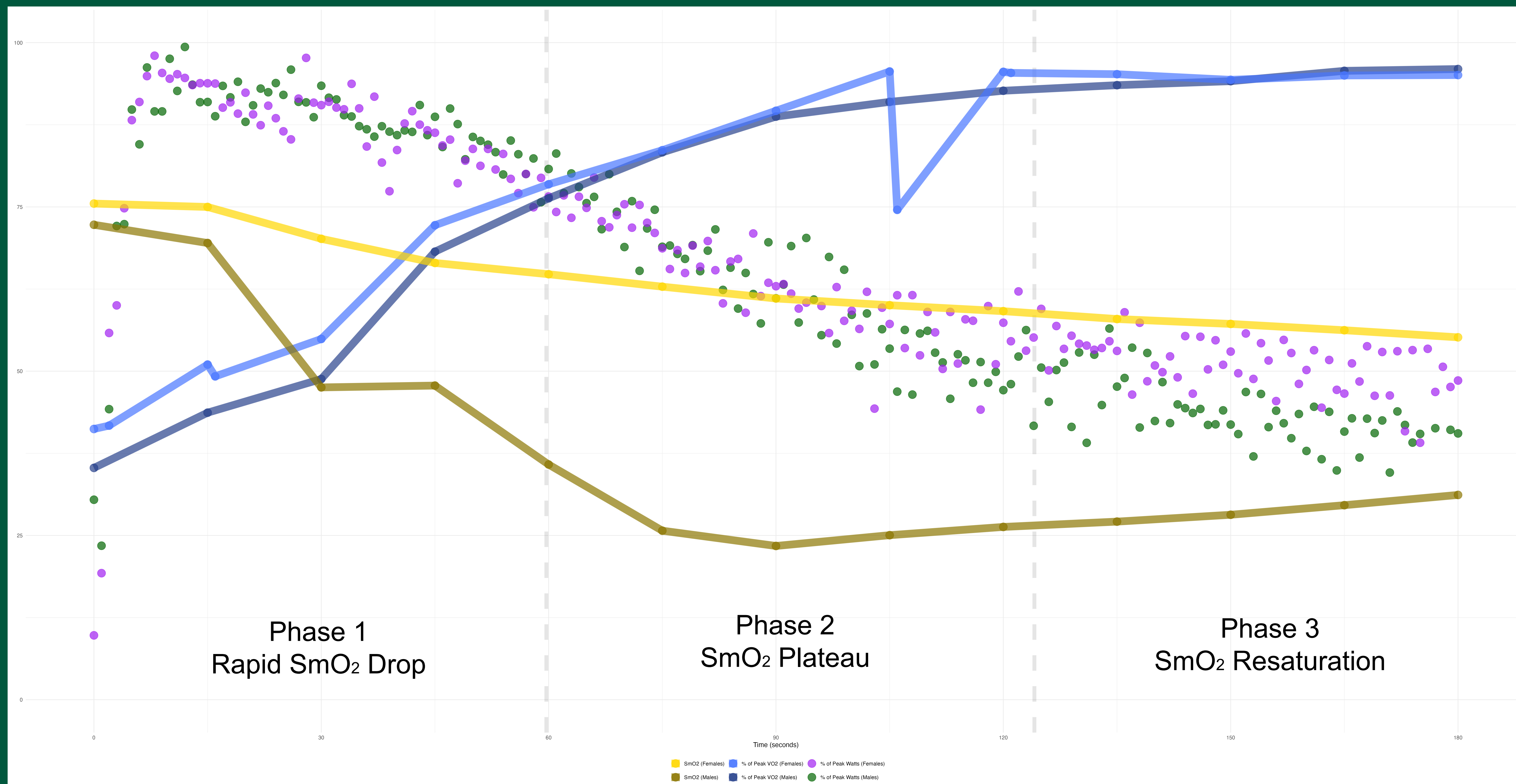
References

1. Jones, AM, Wilkerson, DP, DiMenna, F, Fulford, J, and Poole, DC. Muscle metabolic responses to exercise above and below the "critical power" assessed using 31P-MRS. American Journal of Physiology-Regulatory, Integrative and Comparative Physiology 294: R585-R593, 2008.
2. Burnley, M, Doust, JH, and Vanhatalo, A. A 3-min all-out test to determine peak oxygen uptake and the maximal steady state. Medicine & Science in Sports & Exercise 38: 1995-2003, 2006.

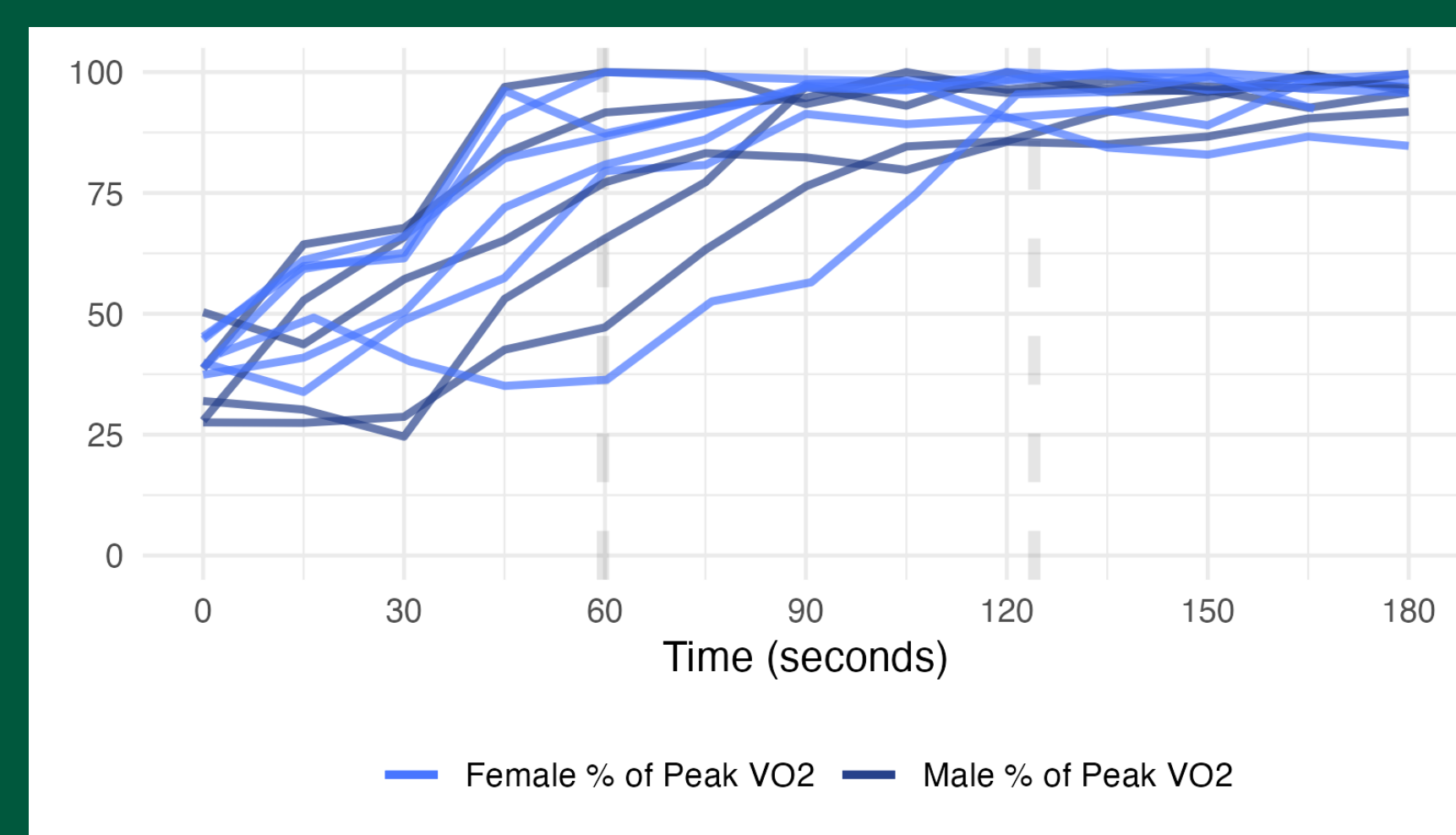
MUSCLE OXYGEN KINETICS DURING A 3-MINUTE ALL-OUT TEST ON INDOOR ROWER

J. Ketterling, P. Phuaklee, and N. Dicks

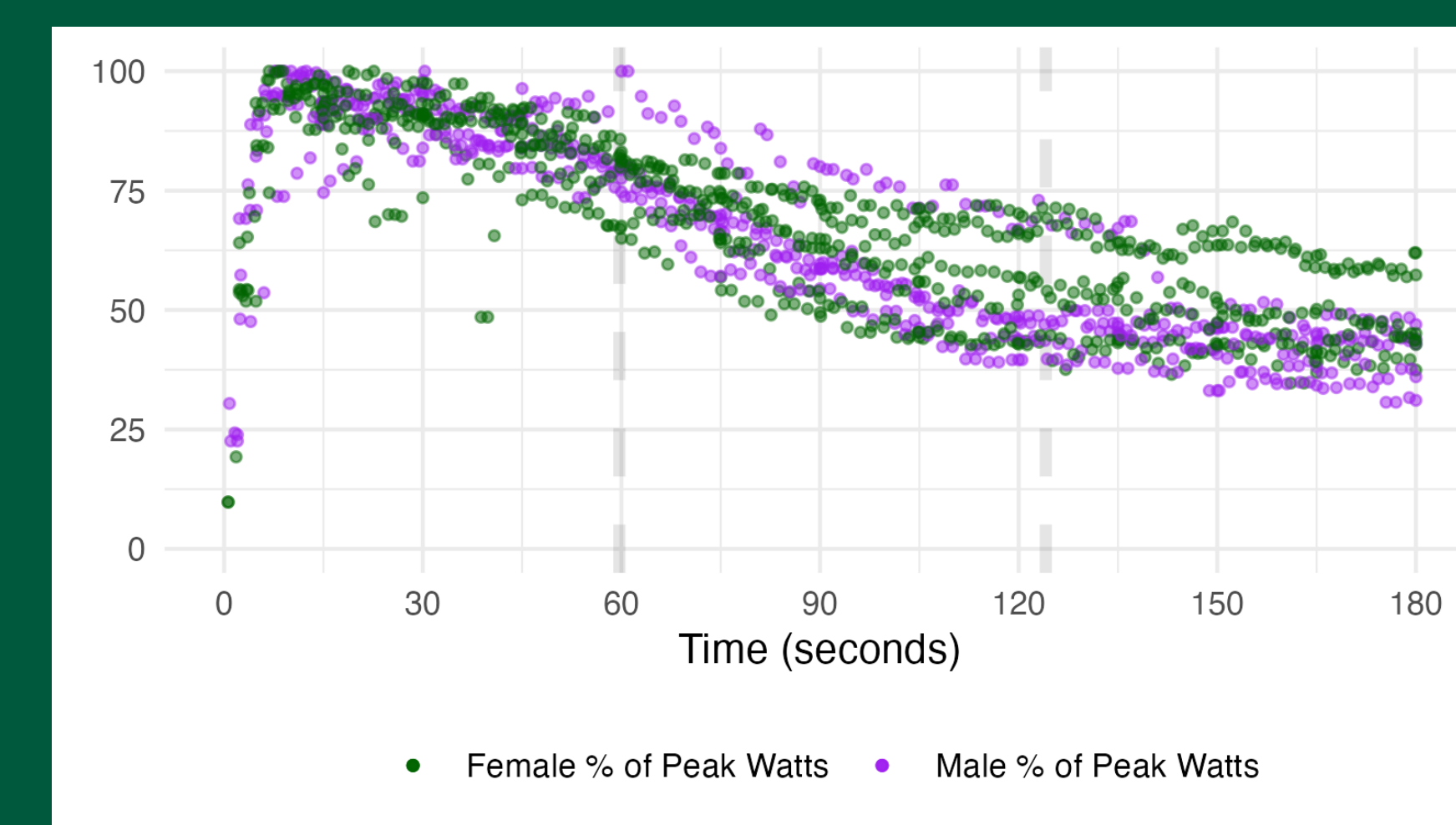
Composite Plot of Average SmO₂, VO₂, and Watts



SmO₂ [%]



% of Peak VO₂

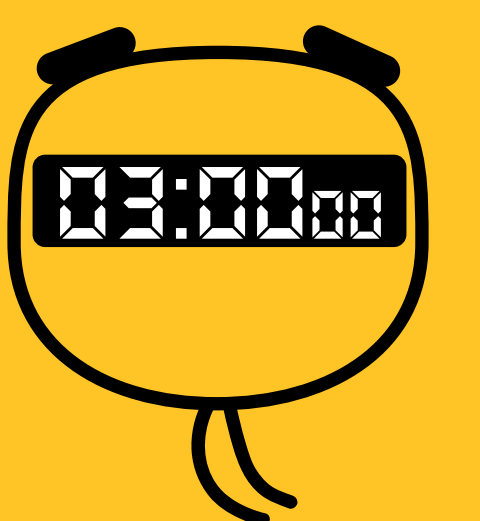


% of Peak Watts



6 Females
5 Males

33
Average Age



3-Minute
All-Out Test



Concept2
RowERG



Moxy
on Vastus Lateralis



VO2 Master

A stabilization of SmO₂ during all-out testing may indicate that the athlete has reached critical power.