We tried to run an example calculation using the W'$_{bal}$ model from your paper [1]:

$$W'_{bal} = W' - \int_0^t W'_{\exp} \cdot e^{\frac{-(t-u)}{\tau_{W'}}} \cdot du$$

Assumption: Recovering below CP for 60 seconds after burning 800 Joules of W' by working above CP.

CP=220, W' = 25400 J, $\tau_{w'}$ = 375 s (values taken from [2] for subject 2),

t=60 s (duration of exercise below CP- assumed), and W'$_{exp}$ = 800 J (assumed)

$$W'_{bal} = 25400 - \int_0^{60} 800 \cdot e^{\frac{-(60-u)}{375}} \cdot du$$

Upon integration,

$$W'_{bal} = 25400 - \left[800 \cdot 375 \cdot e^{\frac{(u-60)}{375}} \right]_{u=0}^{u=60}$$

$$W'_{bal} = 25400 - 800 \cdot 375 \cdot \left[e^{\frac{(60-60)}{375}} - e^{\frac{(0-60)}{375}} \right]$$

$$W'_{bal} = 25400 - 800 \cdot 375 \cdot \left[e^{0} - e^{\frac{-(60)}{375}} \right]$$

$$W'_{bal} = 25400 - 800 \cdot 375 \cdot \left[1 - 0.8521 \right]$$

$$W'_{bal} = 25400 - 800 \cdot 375 \cdot \left[0.1478 \right]$$

$$W'_{bal} = 25400 - 44356.86$$

$$W'_{bal} = -18956.86 J$$

The following are some of the questions we have:

1. The calculations resulted in a negative W'$_{bal}$. Is this possible? What are we doing wrong here?
    a. Is W'$_{exp}$ a constant within the integral?
    b. Is $\tau_{w'}$ a constant for the entire protocol or only for the recovery bouts below CP?
2. Is the model valid for above CP? If so, what happens to the term (t-u) above CP? As you describe it to be the duration of exercise below CP.
3. Could you please show us a similar calculation of W'$_{bal}$ above CP?

References

[1] Shearman, Samantha, et al. "Modeling Intermittent Cycling Performance in Hypoxia Using the Critical Power Concept." *Medicine and science in sports and exercise (2015).*

[2] Skiba, PHILIP FRIERE, et al. "Modeling the expenditure and reconstitution of work capacity above critical power." *Medicine and science in sports and exercise* 44.8 (2012): 1526-1532.