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Abstract

BACKGROUND:

Mobile power meters in cycling have been around since the 1980's and provide a reliable and valid measure of the cyclists' power output [1]. The cyclists' power output is an objective measure of intensity and is independent of the weather conditions and slope. Moreover, it does not have a time delay like a physiological measure (e.g. heart rate). In cycling it is relatively straightforward to calculate the power by measuring the torque on the crank and the angular velocity given by cadence using the following equation:

$$P = T \cdot \omega$$

Where P is the power, T is the torque on the crank and ω is the angular velocity. In kayaking, however, the measurement of power as an objective measure of intensity is a lot more complicated. Here, one would use the linear form of power:

$$P = F \cdot v$$

Here, P is again the power, F could either be the paddle force or the force on the footrest. And v is the velocity. The question is though, the velocity of what? A logical choice would be the velocity of the kayak itself. However, the velocity of the kayak is heavily influenced by environmental conditions. Therefore, we would not obtain an objective measure of the athlete's intensity. The company One Giant Leap claim to measure power in the paddle, but the algorithm used for determining velocity is confidential and not transparent, which makes it difficult to interpret their measures. An alternative could be to calculate the impulse of the paddle force or footrest force over a certain time period. Klitgaard et al. [2] showed a high correlation between the impulse over 10 seconds of the footrest forces and the velocity of the kayak.

In this work, we propose an alternative method to measure the intensity of a kayaking athlete using impulse.

METHODS:

One male national athlete (Age: 20; Body mass: 91.5 kg; Height: 179.5 cm) participated in this study. The athlete did an all-out effort on a 500m on-water kayak sprint. Paddle forces, footrest forces, and velocity were obtained with a sample rate of 100 Hz using the E-kayak system (APlab, Rome, Italy). Bonaiuto et al. [3] has previously described this system in more detail. The paddle forces have both positive and negative values, where the negative values are from the right paddle and the positive ones are from the left. The impulse was calculated as a moving integral of the absolute paddle force values over a window of 5 seconds using the following equation:

$$\boldsymbol{J_{5s}} = \sum_{i}^{i+S\cdot\Delta t} \left|F_{i,paddle}\right| \cdot \frac{1}{S}$$

Here, $\boldsymbol{J_{5s}}$ is the impulse over 5 seconds, S is the sample rate (in this case 100 Hz), $\left|F_{i,paddle}\right|$ is the absolute paddle force of the ith sample, and Δt is the window we integrate over (in this case 5 s). In this way a vector is created, where each element is the impulse of the previous 5 seconds. The impulse will be reported in N·s.

RESULTS:

The athlete paddled the 500 meter in 115 s. Figure 1 shows how the impulse of the paddle forces over 5 seconds changes during the 500 m. Moreover, the velocity has been plotted.

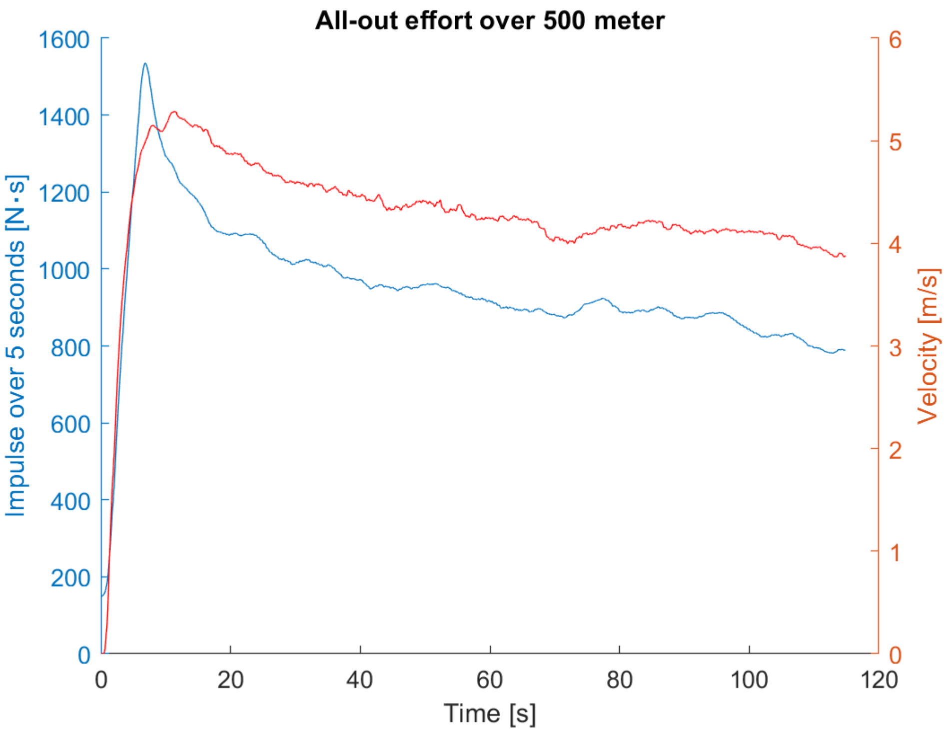

Figure 1: The blue line indicates the development of the impulse of the paddle forces over a window of 5 seconds during an all-out effort over 500 meters. The red line is the velocity.

DISCUSSION:

In this study, we propose to use the impulse of the paddle forces integrated over a window of 5 seconds as a direct measure of the intensity of a kayak athlete. The advantage of using impulse is that the calculation is straightforward, transparent, and mechanically sound. The calculation of impulse is based on the forces delivered by the athlete and is, therefore, independent of environmental conditions. The velocity in figure 1 shows the same development as the 5-second impulse. In a future test setup the same athelete could produce the same impulse in headwind or tailwind, but the velocity would differ between the two conditions.

The impulse was calculated over a window of 5 seconds. Different time intervals where tested, however, it seems that 5 seconds is long enough to contain several strokes and it is short enough to reveal changes over time. The choice of the length of this window is something the kayak community should agree on to make comparisons over time and between athletes.

The interpretation of power output is well developed and accepted by coaches in the cycling world. The interpretation and acceptance of impulse as an intensity measure will need time and more athlete data before kayak athletes and coaches will use it. However, we believe there is great potential that in the kayak community, impulse could be used as an intensity measure like power output is used in the cycling community using wearable devices.

Acknowledgements

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