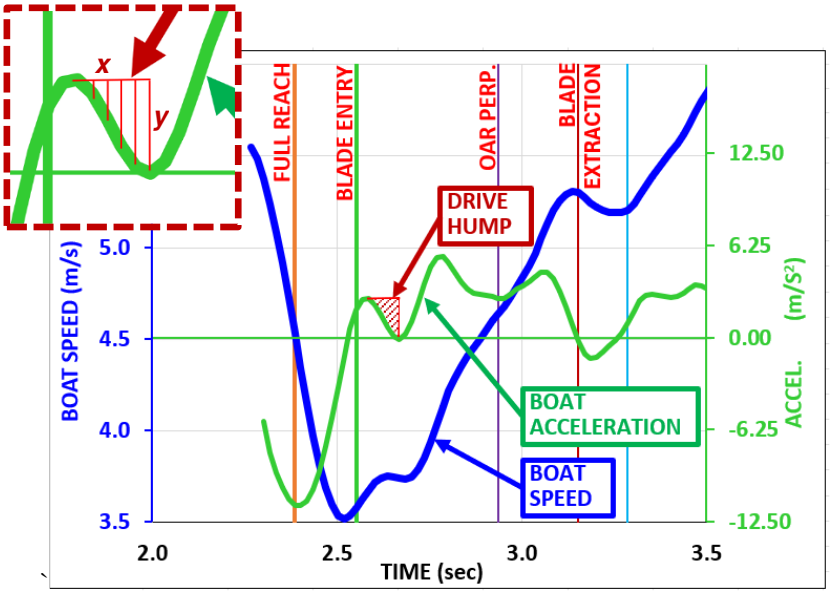
2.9.2 Drive Hump

The Drive Hump is a term first identified by Dr. Varery Kleshnev in his book The Biomechanics of Rowing to identify a reduction in boat acceleration just after the blade entry. This reduced acceleration rate is typical for many crews, and more severe values can result in a loss in boat speed (negative acceleration). Figure 2.9.2a Drive Hump shows boat speed and acceleration curves for the drive phase of the stroke on the right. To the top left, on the figure, is a detailed section of the acceleration curve highlighting the reduced acceleration part just after the entry.

Figure 2.9.2a *Drive Hump*



The drive hump technique factor is the calculated value for the reduced acceleration. It is the loss in acceleration (m/s^2) multiplied by the time. When acceleration slows, the curve tracks downward even though it may still be positive acceleration. Boat acceleration is calculated for each video frame and represents a point on the curve. The drive hump factor value is the sum of the losses in accelerations

multiplied by time for that section. The factor value only calculates the loss in acceleration and ends once the curve starts upward (increasing acceleration).

Figure 2.9.2a, top left, shows the reduced acceleration segments for the video frame time (x) and, the loss in acceleration (y) for each frame. The loss in acceleration represents a negative value making the sum of the losses for the drive hump factor value negative.

$$\textbf{Drive Hump} = x_1 \cdot (-y_1) + x_2 \cdot (-y_2) + x_3 \cdot (-y_3) \ldots$$

Where: x is the time between video frames
y is the loss in acceleration

example: x_1, x_2, x_3 = frame time (0.0167 seconds)
$y_1 = 2.425 - 2.628 = -0.203$
$y_2 = 2.112 - 2.628 = -0.516$
$y_3 = 1.854 - 2.628 = -0.774$
2.628 is the peak acceleration before the loss

The drive hump data for singles and pairs at the World Championships is shown in Figure 2.9.2b Drive Hump Singles Pairs. The vertical axis on the left is the sum of the acceleration losses multiplied by the time. The factor value is negative as all losses are negative.

Figure 2.9.2b *Drive Hump Singles Pairs*

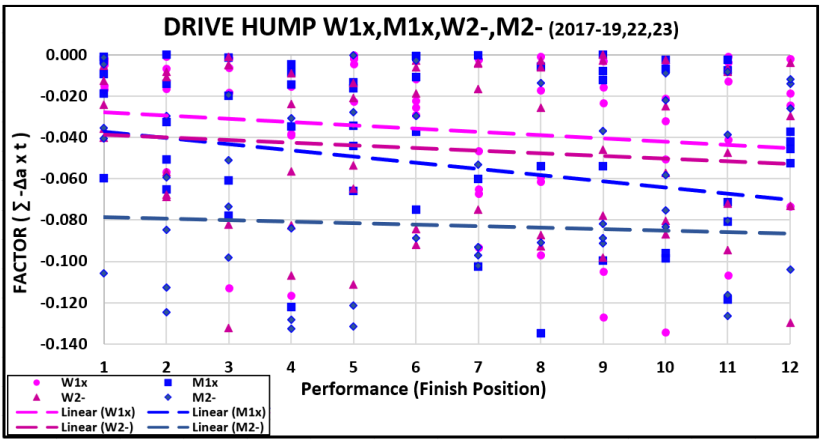


Figure 2.9.2b Drive Hump Singles Pairs includes trendlines for each of the boat classes. The data is very limited; however, the trendlines appear to suggest that the drive hump factor may be related to performance.

Figure 2.9.2c Drive Hump Data shows the values for a variety of boat classes at the World Championships. The data on the chart includes the average drive hump value for crews in each boat class. The chart also includes the standard deviation, minimum and maximum values for each boat class, and the number of crews in the sample.

Figure 2.9.2c *Drive Hump Data*

Boat Class	**Drive Hump**	Standard Deviation	Min.	Max	Data Reference (# of crews)
W1x	**-0.035**	0.045	-0.237	0.000	(59) WC '17,'18,'19,'22,'23
W2x	**-0.041**	0.032	-0.107	0.000	(16) WC '19, '22, '23
W4x	**-0.031**	0.049	-0.188	0.000	(18) WC '17,'23
W2-	**-0.046**	0.040	-0.140	0.000	(59) WC '17,'18,'19,'22,'23
W4-	**-0.064**	0.073	-0.213	0.000	(18) WC '19,'23
W8+	**-0.030**	0.030	-0.106	0.000	(40) WC '17,'18,'19,'22,'23
M1x	**-0.053**	0.055	-0.201	0.000	(59) WC '17,'18,'19,'22,'23
M2x	**-0.057**	0.046	-0.165	0.000	(17) WC' 19,' 22, '23
M4x	**-0.041**	0.052	-0.169	0.000	(14) WC '17,'23
M2-	**-0.083**	0.059	-0.251	0.000	(60) WC '17,'18,'19,'22,'23
M4-	**-0.071**	0.058	-0.213	0.000	(18) WC '17,'19,'23
M8+	**-0.046**	0.051	-0.281	0.000	(51) WC '17,'18,'19,'22,'23

The cause of the reduced boat acceleration is still unknown; however, Dr. Kleshnev has suggested four possible causes in his book (Kleshnev, 2020). 1. Disconnection of the legs and trunk, 2. Double trunk work, 3. Sinking the blade too deeply, 4. Too quick an increase in force.

Coaches can review Section 2.1 Drive and Section 2.1.3 Early Drive for additional details on technique movements and minimizing the reduction in acceleration (drive hump) after the entry.