The Effect of Weight on Kayak Speed by Tom Holloway

Extra weight can make your kayak more stable, however if stability's not a problem then it just tends to slow you down. How much slower will you be if you put on excess body weight? How much faster is a lighter boat? Is the difference worth worrying about?

To help answer these questions let's first consider what various rowing and paddling academics have concluded:

> "*the percentage loss of speed is one sixth (0.167%) the percentage increase in mass"* (Dudhia [1])
>
> *"hull speed goes as the –2/9-th power of weight"* [i.e. 0.222% loss of speed per 1% increase in weight] (Burke [2])
>
> *"The percentage decrease in mean speed is equal to one quarter (0.25%) of the percentage increase in total weight"* (Lazauskas [3])

So there's a range of slightly different theoretical opinions, however they're all saying much the same thing - that kayaks and rowing boats will be about 0.2% slower for every 1% increase in total weight, assuming power output is unchanged.

That's not the end of the story, though. Those values are theoretical, they're not based on real world data, and a number of experienced paddlers (e.g. www.surfskiracing.org [5]) give significantly different answers. They claim on the basis of personal experience that a 1% increase in total weight can slow you down by 0.4%-1.0%, which is up to five times what the theory predicts! Muddying the water further are the small minority of paddlers (e.g. www.roguepaddler.com [6]) who claim that extra weight doesn't slow you down at all.

What should we believe? The theoretical numbers? The opposing claims of real paddlers? Let's take a look at some hard numbers and see if we can find out.

Olympic Rowing Results

Coxed pairs and coxless pairs provide a good case study of the effect of weight on boat speed. These boats have the same hull and "engine"; however coxed doubles are carrying a lot more weight – a 55kg cox, plus a 5kg heavier boat (32kg vs. 27kg). Assuming 2x 90kg rowers and 2x 2.5 kg oars, a coxed pair is 28% heavier than a coxless pair (272kg vs. 212kg).

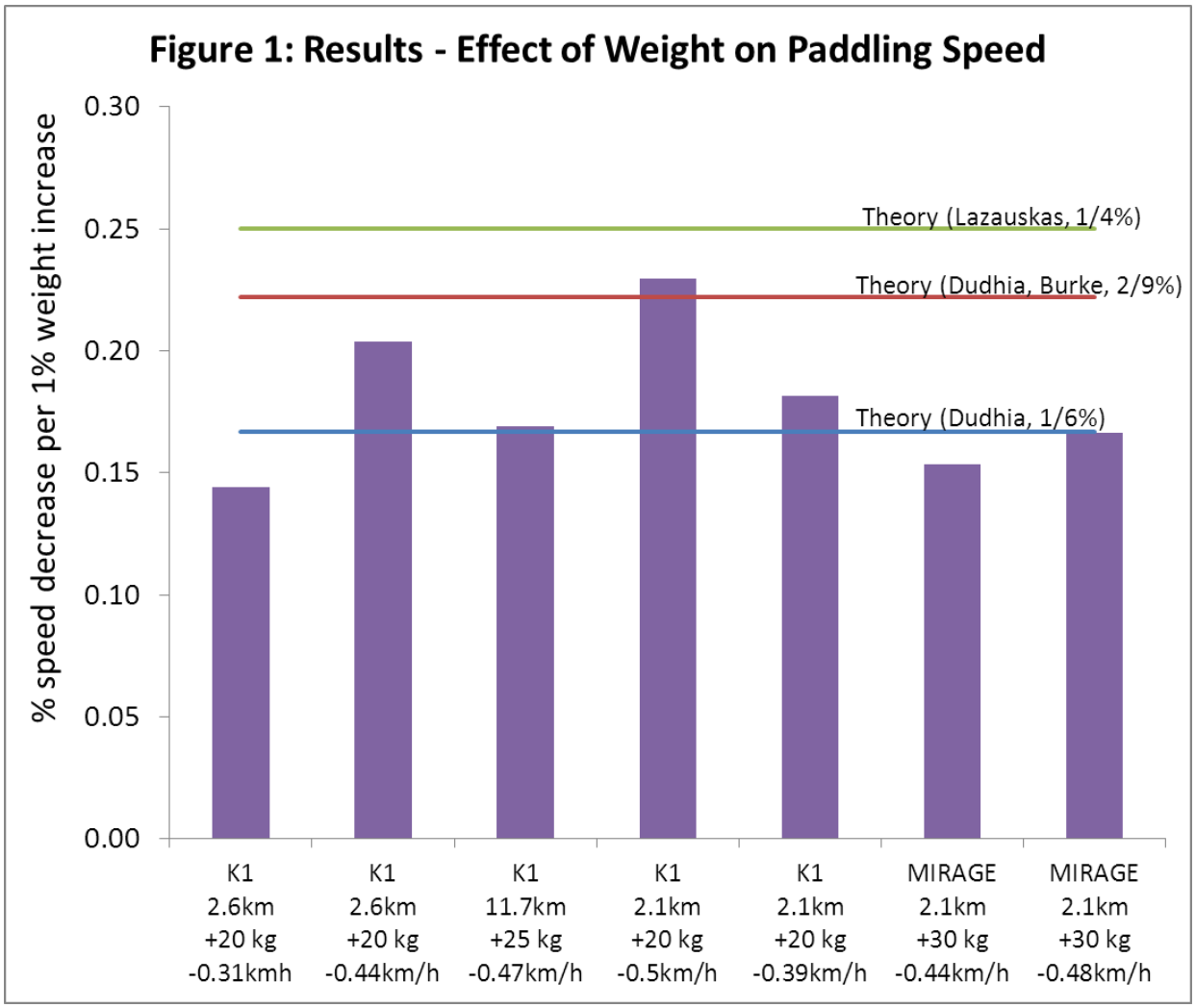
Now the average gold medal time for a coxless pair from 1972 to 1992 was 6:49, and the average time for a coxed pair during the same era was 7:12, a speed decrease of 5.6%. So on average every 1% increase in weight is slowing the coxed boats by approximately 5.6%/28% ~ 0.2%, or more correctly $\log_{1.056}1.28 = 0.22\%$, which falls right in the middle of the theoretical estimates. So far, so good - the theory seems to work - for rowing boats at least! However it was paddlers not rowers who were disputing the theory, so what about kayaks?

Kayak Time Trials

There's no readily available data for kayaks, so to test the effect of weight on kayak speed I paddled a number of time trials in a K1 and a Mirage 530. The time trials were out and back circuits at Narrabeen Lakes and at Wirrong, and ranged in length from 2.1km to 2.6km. I completed each circuit five times in succession, alternating between no extra weight and 20+kg of extra weight, so as to isolate the effect of weight on boat speed. You need a lot of weight to measure the difference.

All trials were done at high tide in relatively calm conditions, and my heart rate remained at a constant 80% throughout. I also paddled our 12km time trial at high tide carrying 25kg to verify the effect over a longer distance.

Figure 1 shows the results compared to the theoretical predictions. Each vertical bar represents one time trial.



The results were consistent and in the same ballpark as the theoretical answers, so it seems fair enough to conclude that the theory is generally correct for kayaks.

Judging from the graph the theoretical 1/6% value (the blue line) gives the best overall prediction, especially for the full 11.7km "12km" distance. So that's our answer – a 1/6% reduction in speed for every 1% increase in weight, which is right back where we started!

Effect on Times

Now that we have an answer, let's take a look at the effect of weight on our Wednesday night time trial.

Consider an average Lane Cove paddler weighing 90kg (including boat, paddle, etc.) who can complete the 12km time trial in 65 minutes. What difference will one extra kilogram make to their time, all else being equal?

New Time = Old Time x (NewWeight/Oldweight)$^{1/6}$ = 65:00 x (91kg/90kg)$^{1/6}$ = 65:07.2

They'll be about 7 seconds slower over 12km. Not a huge amount per se!, however the effect is cumulative. Figure 2 shows the effect of 2.5kg, 5kg, 7.5kg, 10kg, and 12.5kg extra dead weight on our paddler's 12km finishing time.

Figure 2: Effect of extra dead weight on average paddler's 12km finishing time (65 minute 90kg paddler)

So to go one minute faster based on weight alone most of us would need to lose 8 or 9 kg. That's a fair amount, however one minute's improvement is a substantial amount too! Once you've plateaued it's very difficult to break your PB by seconds, let alone by a minute. So losing body fat is clearly a good way to improve your times, assuming you have excess body fat to lose. If you reduce lean body weight you'll be less powerful, which will slow you down. Remember, the theory assumes power is unchanged, and that you can paddle just as hard with or without the extra weight.

Note that faster paddlers and heavier paddlers will see slightly less effect from 1kg change in weight than average paddlers (vice versa for slower paddlers and lighter paddlers). Table 1 shows the effect of 5kg extra dead weight on various different paddlers. See for yourself how a 5kg change in dead weight would affect your times. Alternatively, use the aforementioned equation.

Table 1: Effect of 5kg extra weight on 6k/12k time trial (+min:sec)						
		Current Weight (including boat)				
		60kg	75kg	90kg	105kg	120kg
Current Time	30:00	+0:24	+0:19	+0:16	+0:14	+0:12
	40:00	+0:32	+0:26	+0:22	+0:19	+0:16
	50:00	+0:40	+0:32	+0:27	+0:23	+0:20
	60:00	+0:48	+0:39	+0:33	+0:28	+0:25
	70:00	+0:56	+0:45	+0:38	+0:33	+0:29
	80:00	+1:04	+0:52	+0:43	+0:37	+0:33

Hawkesbury Canoe Classic

How about the Hawkesbury Classic? Assume our paddler can finish in 10 hours. What difference will another kilogram make to their Hawkesbury finishing time?

$$\text{New Time: } = 10{:}00{:}00 \times (91/90)^{1/6} = 10{:}01{:}06$$

They'll be about one minute slower. This won't matter very much for the average paddler, however for those chasing records every minute counts, as several Lane Cove paddlers have found out the hard way over recent years. So if you want to break a record, paddle light – not that potential record breakers really need to be told that! However make sure you carry enough to stay warm and hydrated. If you freeze or run dry you'll lose a lot more than a precious minute!

Conclusion

Flatwater paddlers will be approximately 1/6% slower for every 1% increase in total dead weight, all else being equal.

For a typical single kayak one extra kilogram of dead weight is roughly equivalent to:

- 7 seconds in the 12km Wednesday night time trial.
- 1 minute in the Hawkesbury Classic.

References

[1] Physics of Rowing, Anu Dudhia, *www.atm.ox.ac.uk/rowing/physics/*

[2] Science of Paddling Pt. 1, Shawn Burke, *http://www.surfski.info*

[3] Effect of Weight on Boat Speed, Leo Lazauskas, ROWING SCIENCE NOTES: 7 July 2012

[4] Olympics Database, *www.databaseolympics.com*

[5] Does ski weight make a difference?, *www.surfskiracing.org*

[6] The myth of weight, *www.roguepaddler.com*