CASE STUDIES IN STATISTICAL THINKING

Introduction to swimming data

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The 2015 FINA World Championships

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Strokes at the World Championships

- Freestyle
- Breaststroke
- Butterfly
- Backstroke

Events at the World Championships

- Defined by gender, distance, stroke
- Example: men's 200 m freestyle

Rounds of events

- **Heats**: First round
- **Semifinals**: Penultimate round in some events
- **Finals**: The final round; the winner is champion

Data source

Data are freely available from OMEGA at omegatiming.com

Domain-specific knowledge is

- Imperative
- An absolute pleasure

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Let's practice!

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Do swimmers go faster in the finals?

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Michael Phelps's personal bests

Event	Time	Venue	Date	Round
100 m free	47.51	Beijing	2008-08-11	Final
200 m free	1:42.96	Beijing	2008-08-12	Final
400 m free	3:47.79	Indianapolis	2005-04-01	Final
100 m back	53.01	Indianapolis	2007-08-03	Final
200 m back	1:54.65	Indianapolis	2007-08-01	Final
100 m breast	1:02.57	Columbia	2008-02-17	Final
200 m breast	2:11.30	San Antonio	2015-08-10	Final
100 m fly	49.82	Rome	2009-08-01	Final
200 m fly	1:51.51	Rome	2009-29-07	Final
200 m IM	1:54.16	Shanghai	2011-07-28	Final
400 m IM	4:03.84	Beijing	2008-08-10	Final

Sarah Sjöström's personal bests

Event	Time	Venue	Date	Round
50 m free	23.67	Budapest	2017-07-29	Semifinal
100 m free	51.71	Budapest	2017-07-23	Final
200 m free	1.54.08	Rio de Janeiro	2016-08-09	Final
400 m free	4.06.04	Amiens	2014-03-16	Final
50 m back	27.80	Borås	2017-06-30	Final
100 m back	59.98	Eindhoven	2015-04-05	Final

Your question

Do swimmers swim faster in the finals than in other rounds?

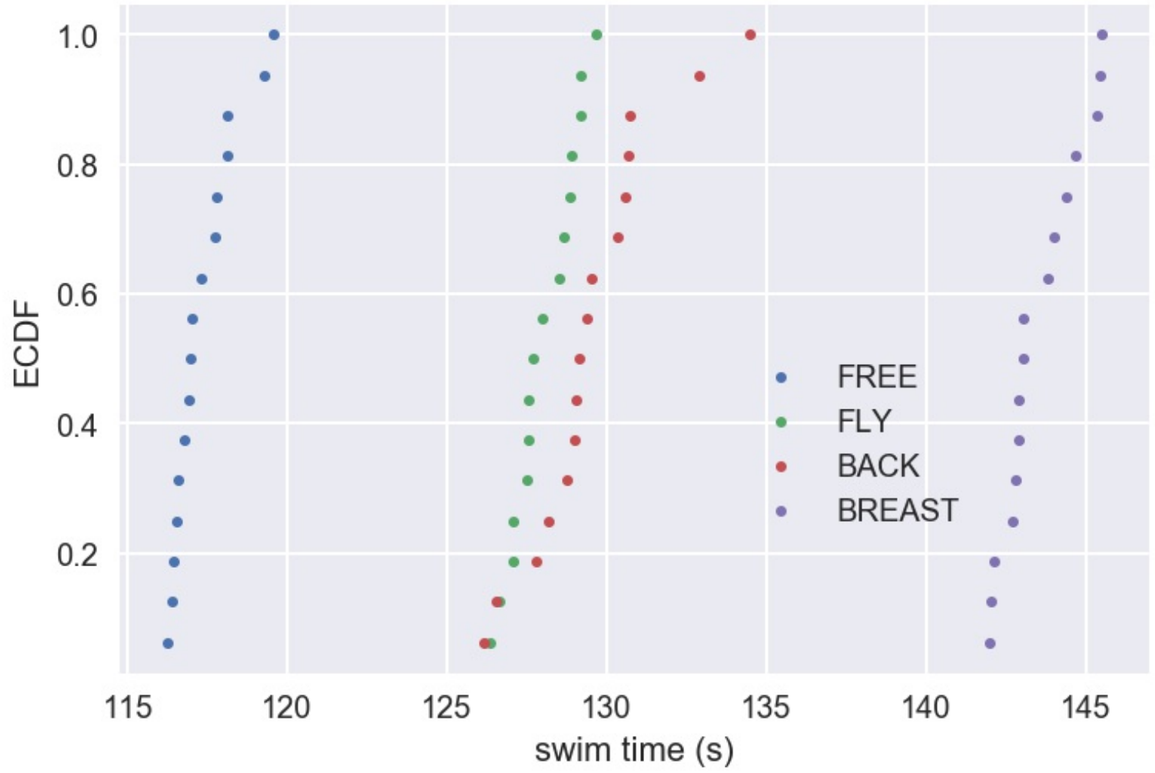
- Individual swimmers, or the whole field?
- Faster than heats? Faster than semifinals?
- For what strokes? For what distances?

Your question

Do individual female swimmers swim faster in the finals compared to the semifinals?

Events: 50, 100, 200 meter freestyle, breststroke, butterfly, backstroke

Diff'rent strokes



Fractional improvement

$$f = \frac{\text{semifinals time} - \text{finals time}}{\text{semifinals time}}$$

Your question(s)

Original question:

- Do swimmers swim faster in the finals than in other rounds?

Sharpened questions:

- What is the fractional improvement of individual female swimmers from the semifinals to the finals?

- Is the observed fractional improvement commensurate with there being no difference in performance in the semifinals and finals?

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How does the performance of swimmers decline over long events?

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More swimming background

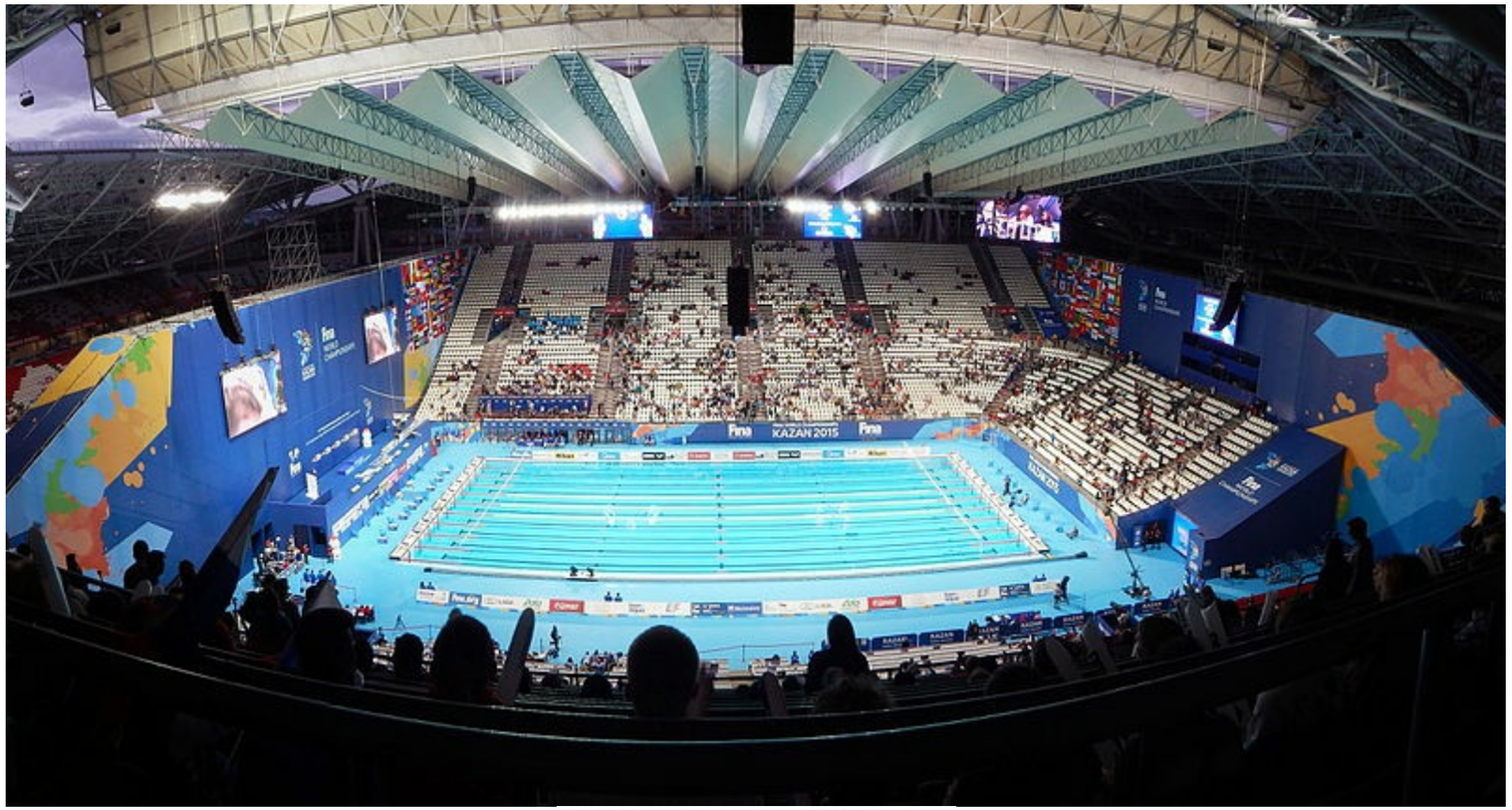
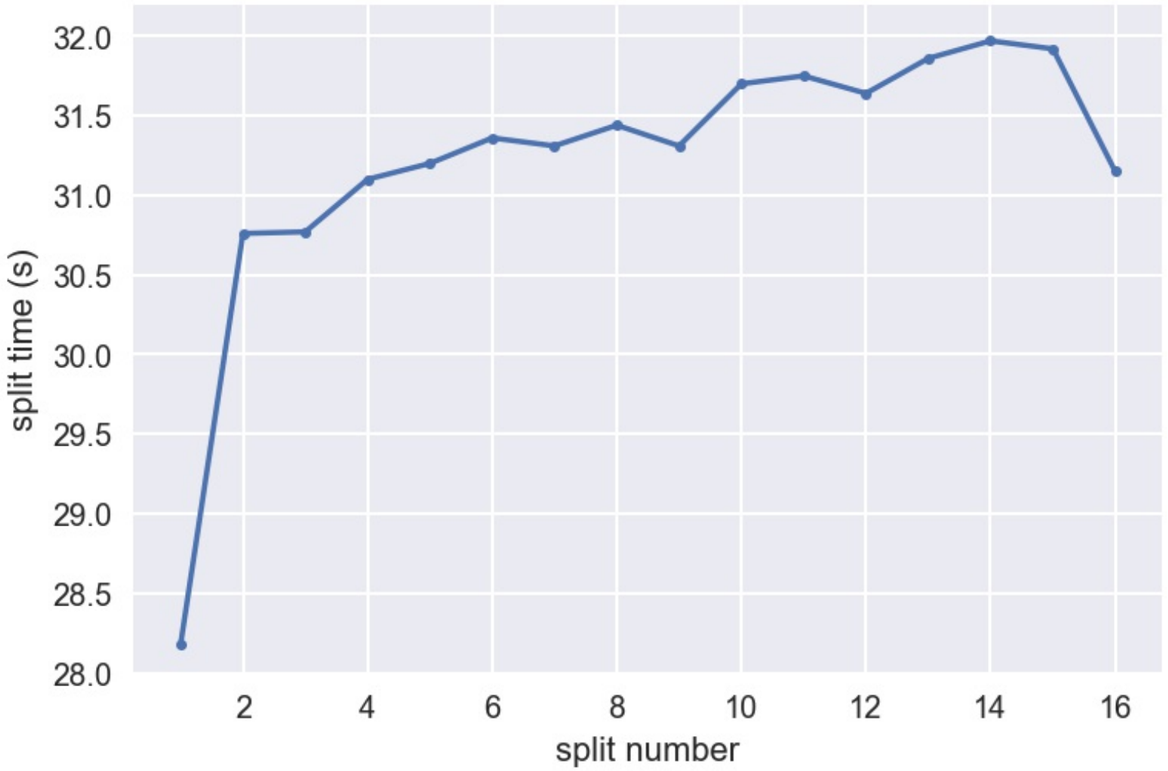


Photo by Chan-Fan, CC-BY-SA-4.0

More swimming background

- **Split**: The time is takes to swim one length of the pool

More swimming background



More swimming background

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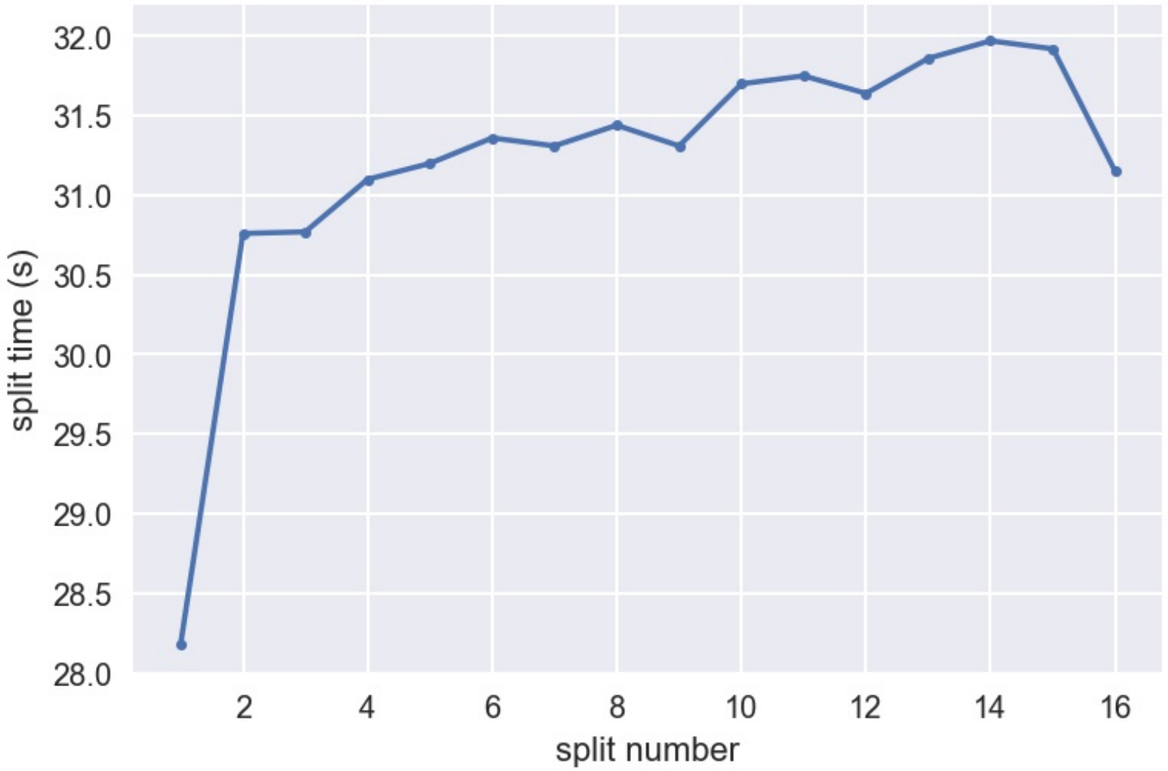
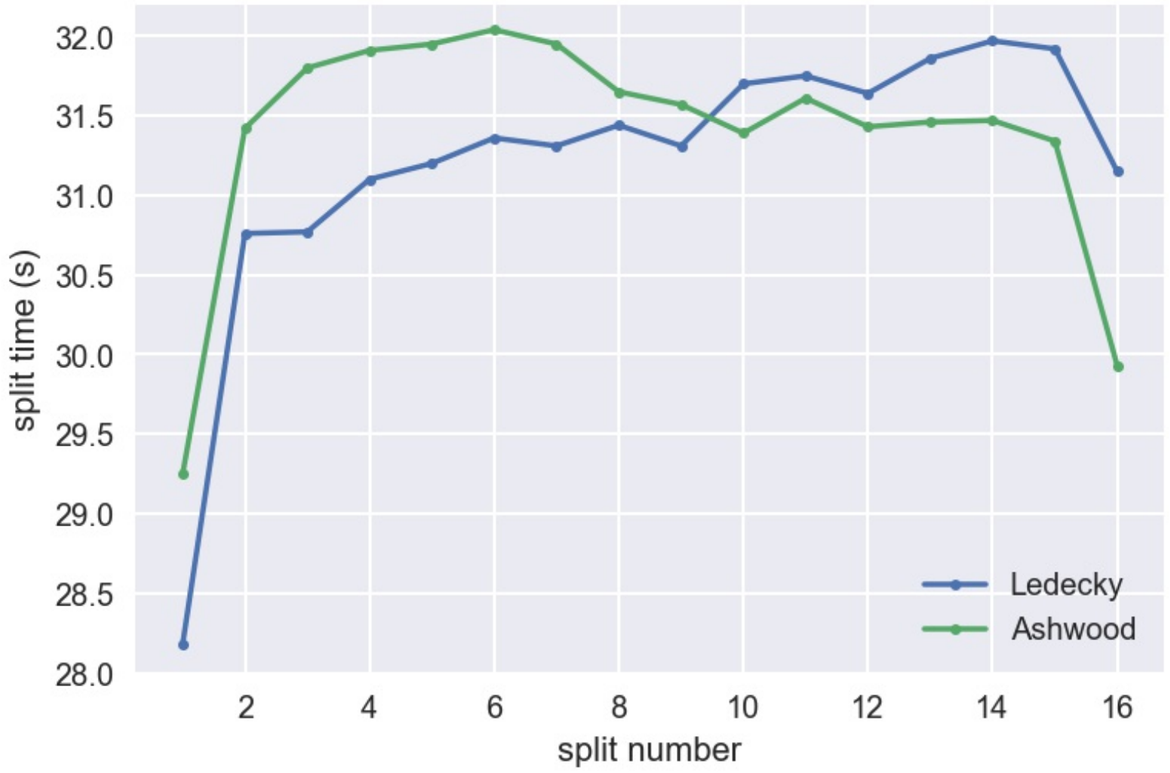
More swimming background



Slowing down



Quantifying slowdown

- Use women's 800 m freestyle heats
- Omit first and last 100 meters
- Compute mean split time for each split number
- Perform linear regression to get slowdown per split
- Perform hypothesis test: can the slowdown be explained by random variation?

Hypothesis tests for correlation

- Posit null hypothesis: split time and split number are completely uncorrelated
- Simulate data assuming null hypothesis is true

```
scrambled_split_number = np.random.permutation(split_number)
```

- Use Pearson correlation, ρ, as test statistic

```
rho = dcst.pearson_r(scrambled_split_number, splits)
```

- Compute p-value as the fraction of replicates that have ρ at least as large as observed

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