



# Pacing Profiles in World Championship 2000m Rowing: Explored through k-Shape Clustering

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# Outline

- ▶ World Championship 2000m Rowing Data
- ▶ k-Shape Clustering
- ▶ Factors associated with Pacing Profiles
- ▶ Limitations and Future Work

# Data

[www.worldrowing.com](http://www.worldrowing.com):

- ▶ Olympics
- ▶ Paralympics
- ▶ **World Championships**
- ▶ World Cups
- ▶ Continental
- ▶ Under 23
- ▶ Junior
- ▶ Continental

# Data: www.worldrowing.com



24 September - 1 October 2017

**Media Start List**

**Lightweight Men's Four**

**27 SEP 2017**

**LM4-**

**X**

**Race 125**

World Champ Best: DEN JOERGENSEN / LARSEN / BARSDØ / JOERGENSEN Amsterdam (NED) 2014 World Championships 5:43.16

World Best Time: DEN JOERGENSEN / LARSEN / BARSDØ / JOERGENSEN Amsterdam (NED) 2014 World Championships 5:43.16


World Champions: SUI TRAMER / SCHUECHER / NEPMANN / OYR Augsburg (GER) 2015 World Championships 5:58.31

Start Time: 13:36

REVISED 25 SEP 14:47

Lane	City Code	Name	Date of Birth
1	USA	(1) FOSTER Thomas (2) DAVIS Nicholas (3) SMITH David (4) NEILS Andrew	19 MAR 1994 26 AUG 1987 17 FEB 1996 27 JUN 1985
2	CHN	(1) XIAOWANG (2) WANG Tian (3) YU Chenggang (4) ZHANG Jinglin	19 MAR 1987 24 FEB 1990 19 APR 1994 19 APR 1999
3	GER	(1) STOECKER Patrick (2) KESSLER Sven (3) KOCH Jonathan (4) PESCHEL Julius	22 JUL 1992 22 MAR 1991 20 OCT 1990 31 OCT 1990
4	HUN	(1) PÁLFI Balázs (2) CSIZSÁR Péter (3) TÁMÁS Benke (4) RIPPESCH Peter	01 DEC 1994 30 MAR 1994 02 JUN 1992 25 SEP 1991
5	RUS	(1) TELICHYN Maksim (2) BOGDANSKI Aleksandr (3) CHAIKIN Alexander (4) WELIKH Andrey	28 DEC 1990 20 OCT 1994 22 APR 1988 16 DEC 1992
6	ITA	(1) DUCHICHI Federico (2) BARBARO Leone (3) TEBESCO Lorenzo (4) SPILIGLI Piero	19 JUL 1993 20 OCT 1990 20 DEC 1990 03 JUN 1994





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Dist.	USA	CHN	GER	HUN	RUS	ITA
[m]	Stroke [m/s]	Stroke [m/s]	Stroke [m/s]	Stroke [m/s]	Stroke [m/s]	Stroke [m/s]
25	4.6	4.4	5.3	5.0	5.1	4.8
50	5.6	4.6	5.8	5.1	5.3	4.7
75	5.6	4.6	5.8	5.1	5.3	4.7
100	5.6	4.6	5.8	5.1	5.3	4.7
125	5.6	4.6	5.8	5.1	5.3	4.7
150	5.6	4.6	5.8	5.1	5.3	4.7
175	5.6	4.6	5.8	5.1	5.3	4.7
200	5.6	4.6	5.8	5.1	5.3	4.7
225	5.6	4.6	5.8	5.1	5.3	4.7
250	5.6	4.6	5.8	5.1	5.3	4.7
275	5.6	4.6	5.8	5.1	5.3	4.7
300	5.6	4.6	5.8	5.1	5.3	4.7
325	5.6	4.6	5.8	5.1	5.3	4.7
350	5.6	4.6	5.8	5.1	5.3	4.7
375	5.6	4.6	5.8	5.1	5.3	4.7
400	5.6	4.6	5.8	5.1	5.3	4.7
425	5.6	4.6	5.8	5.1	5.3	4.7
450	5.6	4.6	5.8	5.1	5.3	4.7
475	5.6	4.6	5.8	5.1	5.3	4.7
500	5.6	4.6	5.8	5.1	5.3	4.7
525	5.6	4.6	5.8	5.1	5.3	4.7
550	5.6	4.6	5.8	5.1	5.3	4.7
575	5.6	4.6	5.8	5.1	5.3	4.7
600	5.6	4.6	5.8	5.1	5.3	4.7
625	5.6	4.6	5.8	5.1	5.3	4.7
650	5.6	4.6	5.8	5.1	5.3	4.7
675	5.6	4.6	5.8	5.1	5.3	4.7
700	5.6	4.6	5.8	5.1	5.3	4.7
725	5.6	4.6	5.8	5.1	5.3	4.7
750	5.6	4.6	5.8	5.1	5.3	4.7
775	5.6	4.6	5.8	5.1	5.3	4.7
800	5.6	4.6	5.8	5.1	5.3	4.7
825	5.6	4.6	5.8	5.1	5.3	4.7
850	5.6	4.6	5.8	5.1	5.3	4.7
875	5.6	4.6	5.8	5.1	5.3	4.7
900	5.6	4.6	5.8	5.1	5.3	4.7
925	5.6	4.6	5.8	5.1	5.3	4.7





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**Results**

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Start Time: 13:36

Rank	Lane	City Code	Name	500m	1000m	1500m	2000m	Prog. Code
1	6	ITA	(1) DUCHICHI Federico (2) BARBARO Leone (3) TEBESCO Lorenzo (4) SPILIGLI Piero	1:29.28 (1)	2:58.30 (1)	4:29.64 (1)	6:01.82 (1)	FA
2	5	RUS	(1) TELICHYN Maksim (2) BOGDANSKI Aleksandr (3) CHAIKIN Alexander (4) WELIKH Andrey	1:29.97 (4)	3:01.10 (2)	4:33.58 (2)	6:07.05 (2)	FA
3	3	GER	(1) STOECKER Patrick (2) KESSLER Sven (3) KOCH Jonathan (4) PESCHEL Julius	1:31.05 (3)	3:03.62 (3)	4:36.42 (3)	6:09.37 (3)	FA
4	2	CHN	(1) XIAOWANG (2) WANG Tian (3) YU Chenggang (4) ZHANG Jinglin	1:32.32 (4)	3:07.48 (4)	4:38.62 (4)	6:10.95 (4)	FA
5	1	USA	(1) FOSTER Thomas (2) DAVIS Nicholas (3) SMITH David (4) NEILS Andrew	1:36.48 (5)	3:11.11 (5)	4:47.80 (5)	6:28.63 (5)	FA
6	4	HUN	(1) PÁLFI Balázs (2) CSIZSÁR Péter (3) TÁMÁS Benke (4) RIPPESCH Peter	1:38.40 (6)	3:16.78 (6)	4:50.96 (6)	6:46.17 (6)	FA



## Media Start List

## Race Data

## Results



## Data: [www.worldrowing.com](http://www.worldrowing.com)

1. Scrape PDF files from World Championships
2. For each race, extract data from the 3 PDFs
3. Join the race data from the 3 PDFs
4. Combine all races into one file
5. Make code and data available on github!

[github.com/danichusfu/rowing\\_pacing\\_profiles](https://github.com/danichusfu/rowing_pacing_profiles)

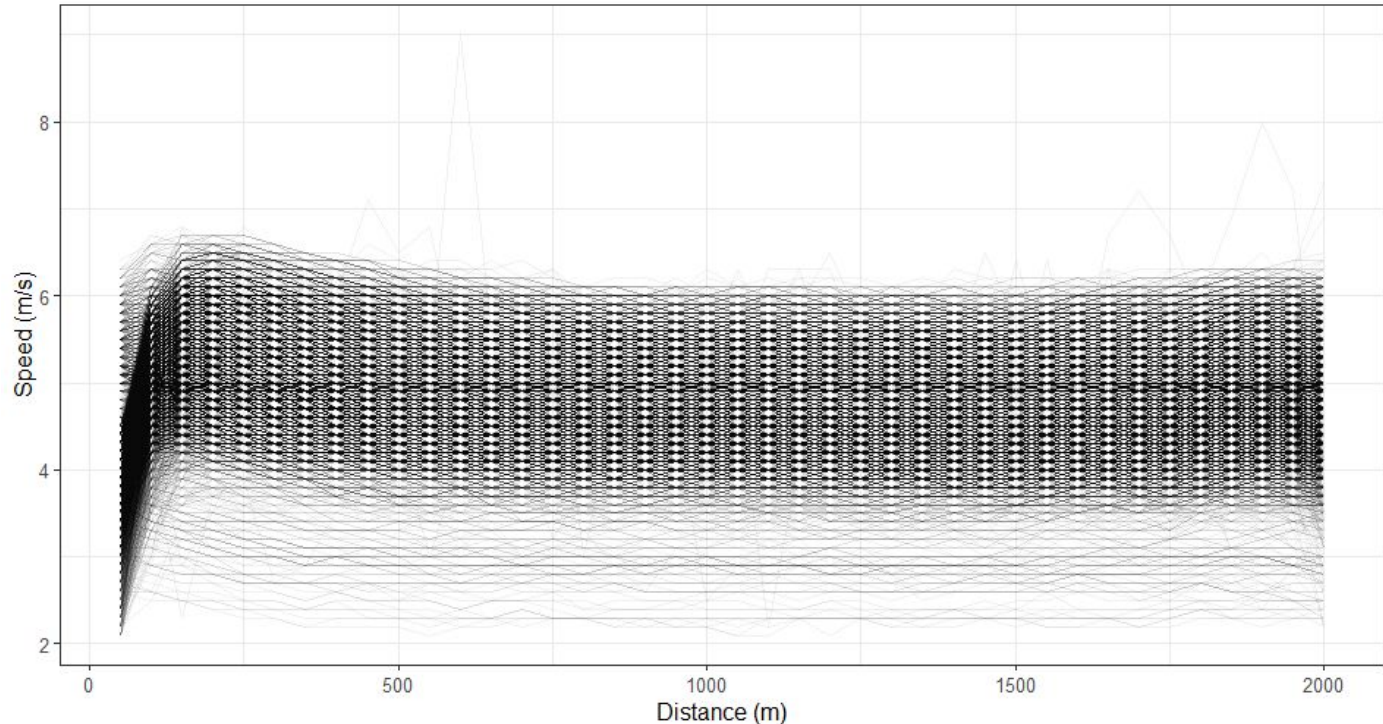
# Goals!

- ▶ Identify the pacing profiles being used by each boat in World Championship 2000m Rowing
- ▶ Identify which race factors are associated with exhibiting a pacing profile

# Identification of Pacing Profiles

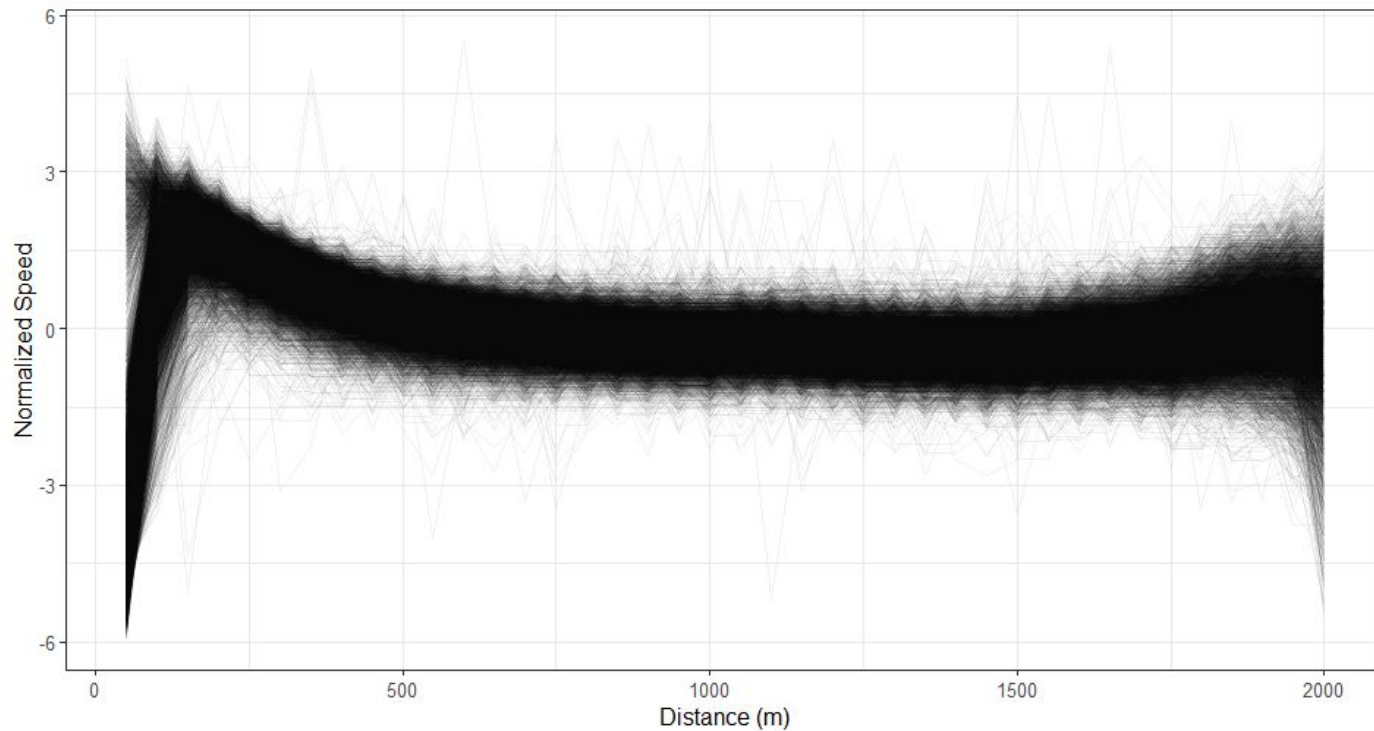
- ▶ Cluster boats based on their average speed at each 50m split
- ▶ Problems:
  - Longitudinal data
  - Magnitudes of average speed depend on factors such as boat size, weight class, age group and gender

# Raw Speed Curves





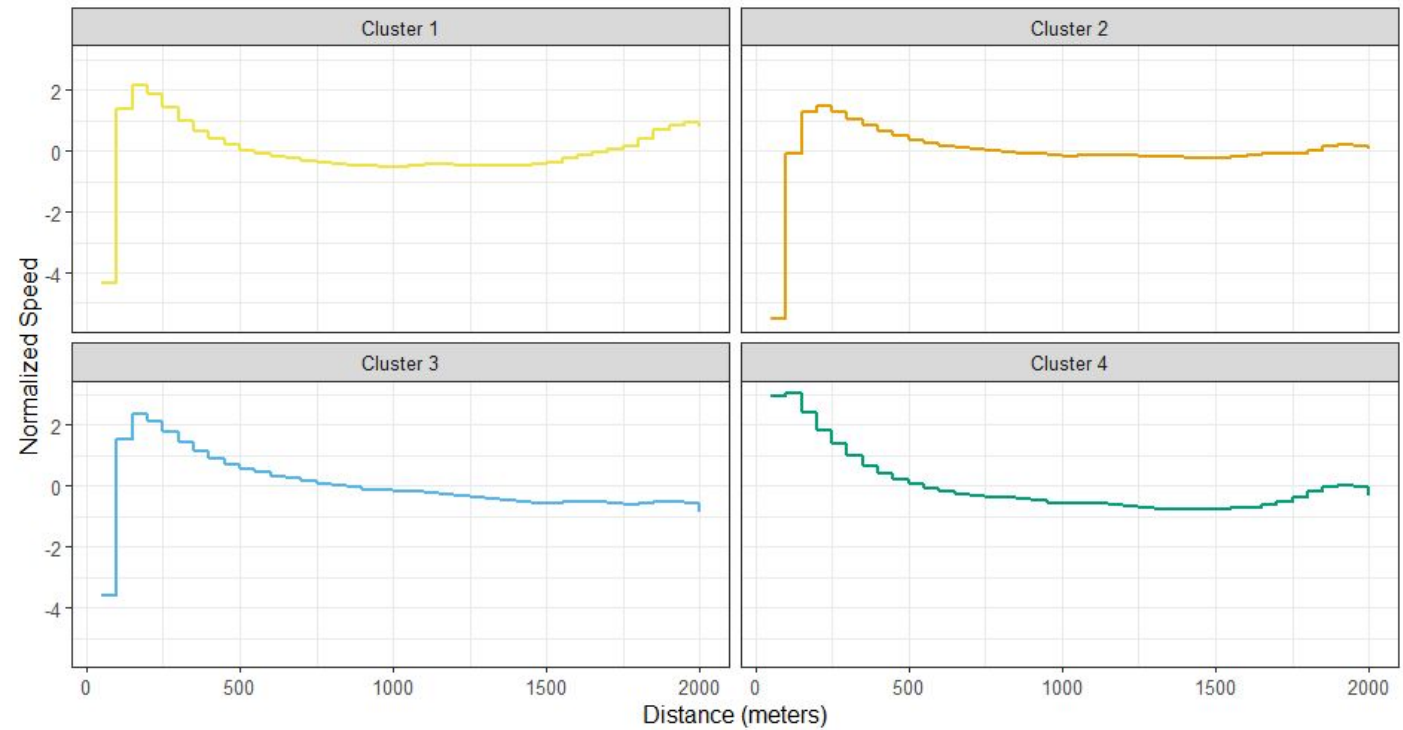
# Normalized Speed Curves



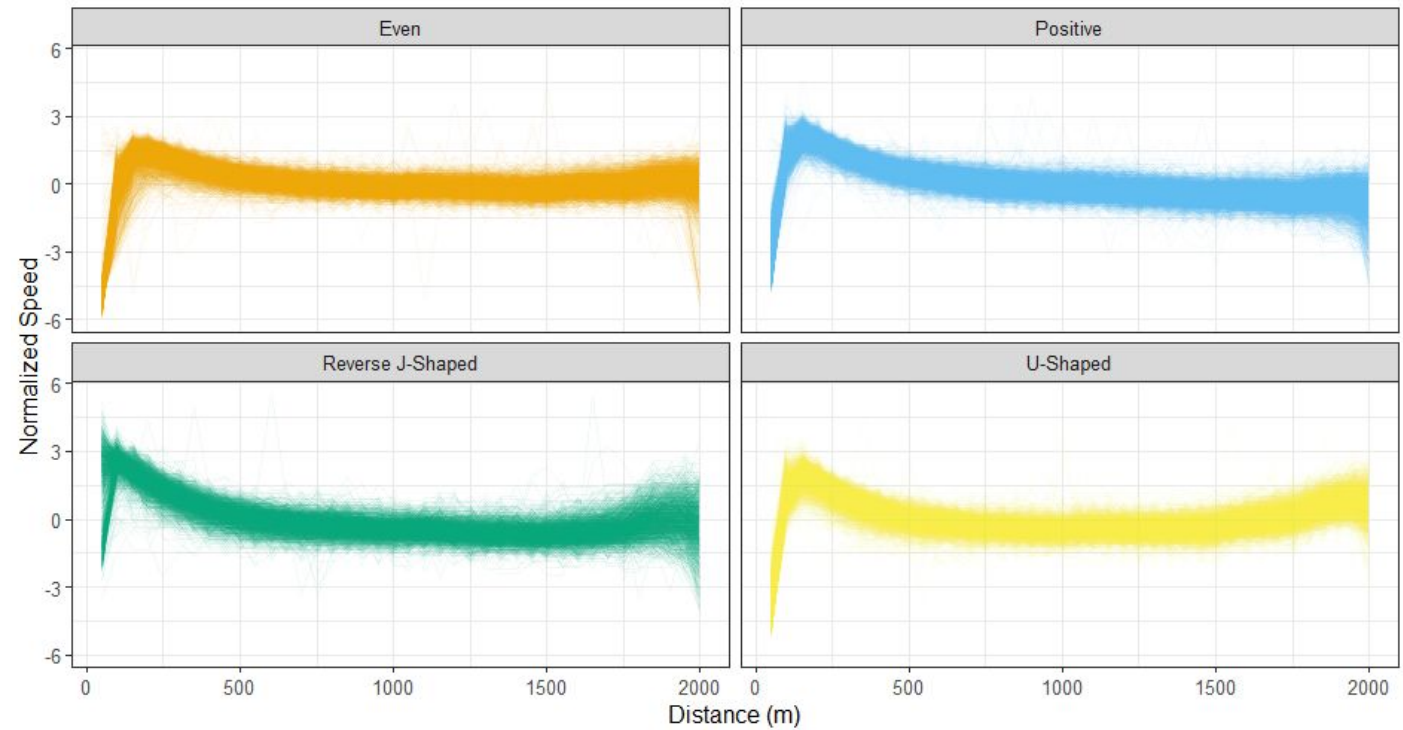
## k-Shape Clustering

- ▶ Uses Shape-based distance (SBD) as an alternative to Dynamic Time Warping (DTW)
- ▶ SBD is computationally more efficient than DTW
  - $O(m \log(m))$  to  $O(m^2)$
- ▶ Small sacrifice in accuracy in experimental settings

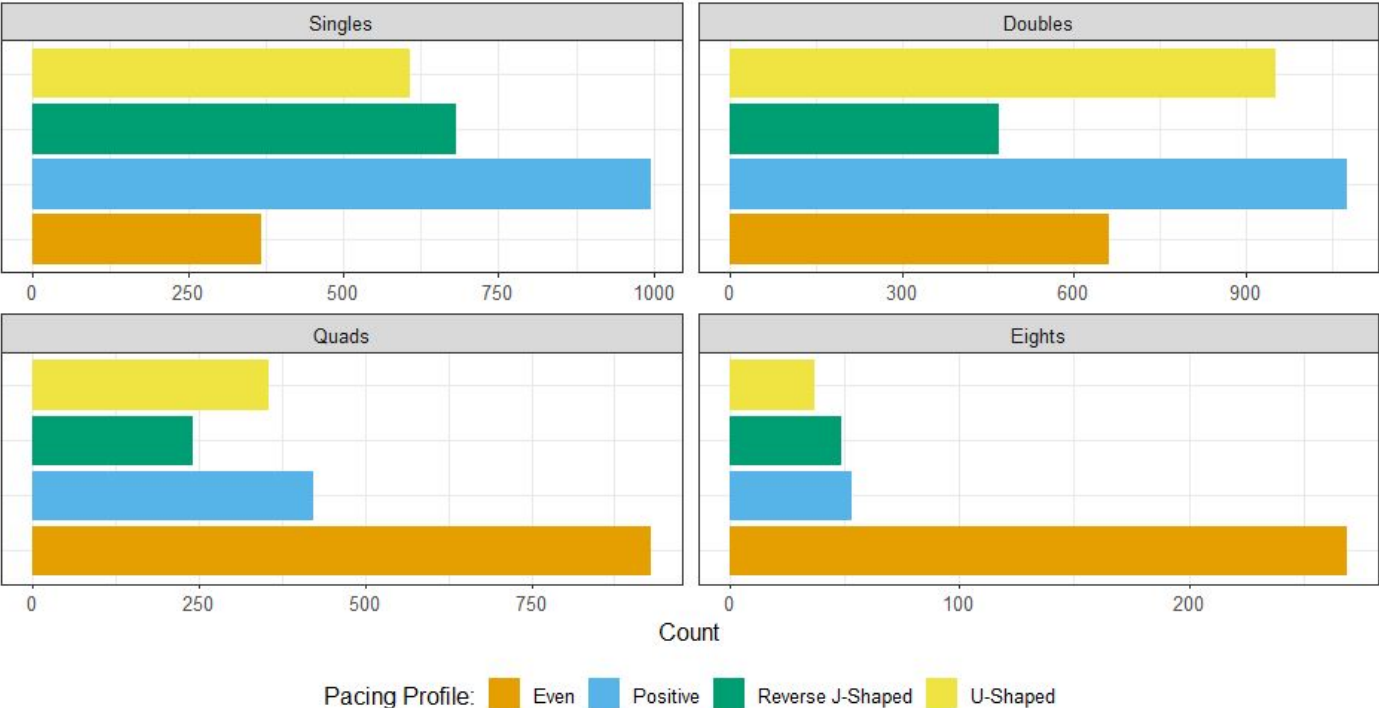
# Cluster Centroids



# Pacing Profiles



# Boat Sizes



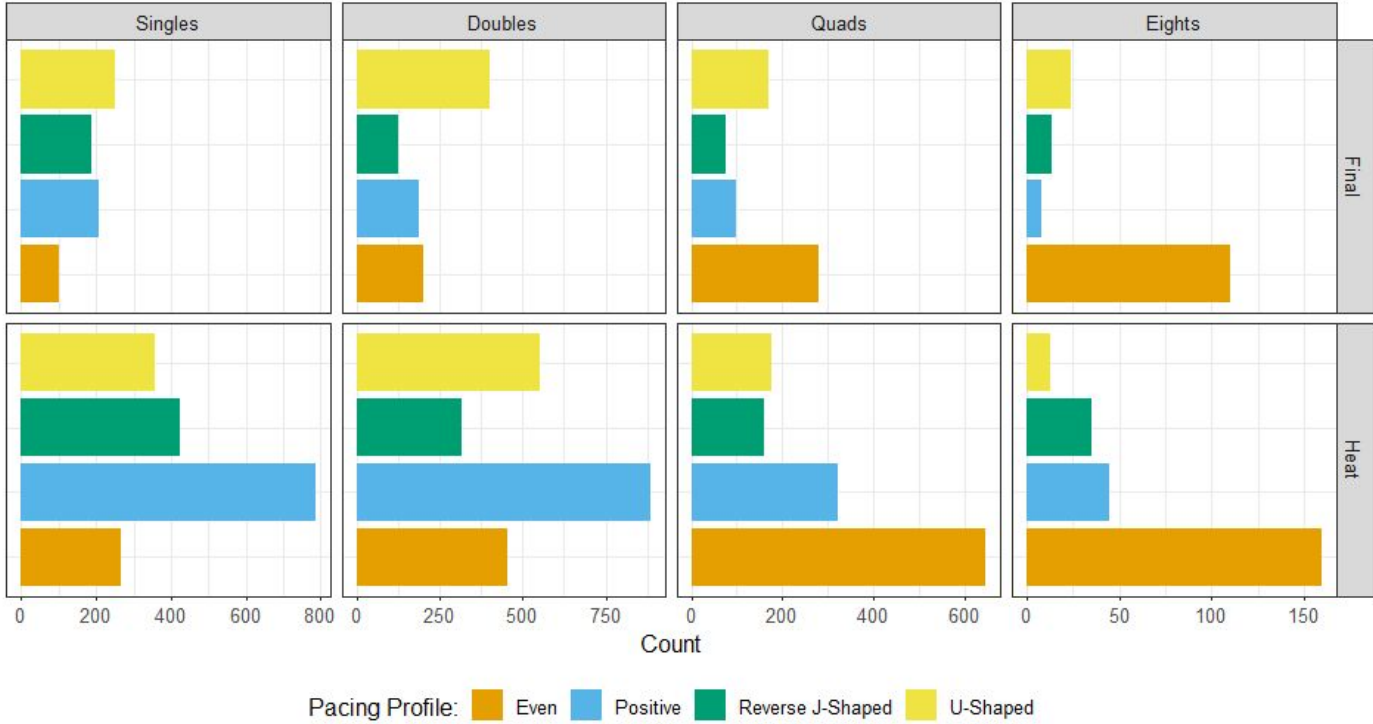
# Modelling Pacing Profiles

- ▶ Response variable is the identified pacing profile
- ▶ Modelled as a function of race factors
- ▶ Using multinomial logistic regression
  - Even profile is the baseline
  - Report the relative risk ratio for a one-unit increase in the variable

# Model Results

	Positive	Reverse J-Shaped	U-Shaped
Intercept	0.90	0.77	1.41
Size: Doubles	<b>0.48</b>	<b>0.38</b>	<b>0.68</b>
Size: Quads	<b>0.13</b>	<b>0.14</b>	<b>0.16</b>
Size: Eights	<b>0.04</b>	<b>0.08</b>	<b>0.04</b>
Heat or Final: Heat	<b>1.81</b>	1.04	<b>0.54</b>
Race Placement: 2nd Place	0.86	1.02	1.21
Race Placement: 3rd Place	1.08	1.33	<b>1.50</b>
Race Placement: 4th Place	1.36	<b>1.60</b>	<b>1.60</b>
Race Placement: 5th Place	<b>1.76</b>	<b>1.93</b>	1.24
Race Placement: 6th Place	<b>3.16</b>	<b>3.16</b>	1.21
Discipline: Sweep	<b>1.81</b>	1.20	<b>1.97</b>
Gender: Women	<b>1.88</b>	<b>1.68</b>	<b>1.66</b>
Weight Class: Open	<b>1.43</b>	<b>1.52</b>	<b>1.28</b>

# Boat Sizes and Heat/Final





# Boat Sizes, Heat/Final and Placement



# Conclusions

- ▶ Can identify pacing profiles with k-Shape Clustering
- ▶ Interesting preliminary results for which race factors affect pacing profiles
- ▶ Available data:  
[github.com/danichusfu/rowing\\_pacing\\_profiles](https://github.com/danichusfu/rowing_pacing_profiles)
- ▶ I'd love your feedback and thoughts!

# Limitations

- ▶ Observational Data
- ▶ Interaction terms are not fit in the model
- ▶ Cannot choose a “optimal” profile to help coaches and athletes
- ▶ Only uses World Championship Races

**THANKS!**

# Any Questions?

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