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Pacing Profiles in World Championship 2000m Rowing:

Explored through k-Shape Clustering

Dani Chu, Ryan Sheehan, Dr. Jack Davis, and Dr. Ming Chang-Tsai

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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:

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

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Data: www.worldrowing.com

2017 world rowing championships — Sarasota-Bradenton Florida, USA — we welcome the world

WCH Sarasota-Bradenton, USA — 24 September - 1 October 2017

10 (Event) — **Media Start List** — Lightweight Men's Four — 27 SEP 2017 — LM4- X Race 125

Start Time: 13:36

REVISED 26 SEP 14:07

World Champ/ Best:	DEN	JOERGENSEN / LARSEN / BARSOE / JOERGENSEN	Amsterdam (NED) 2014	World Champ'ships 5:43.16
World Best Time:	DEN	JOERGENSEN / LARSEN / BARSOE / JOERGENSEN	Amsterdam (NED) 2014	World Champ'ships 5:43.16
World Champion:	SUI	TRAMER / SCHUERCH / NIEPMANN / GYR	Aiguebelette (FRA) 2015	World Champ'ships 5:55.31

Lane	Ctry Code		Name	Date of Birth
1	USA	(b)	FOSTER Thomas	19 MAR 1994
		(2)	DAWE Nicholas	26 AUG 1987
		(3)	SMITH David	17 FEB 1986
		(s)	NEILS Andrew	27 JUN 1985
2	CHN	(b)	LI Xiaoxiong	18 MAR 1987
		(2)	WANG Tiexin	24 FEB 1989
		(3)	YU Chenggang	23 FEB 1984
		(s)	ZHAO Jinglin	18 APR 1990
3	GER	(b)	STOECKER Patrik	23 JUL 1992
		(2)	KESSLER Sven	22 MAR 1991
		(3)	KOCH Jonathan	29 OCT 1985
		(s)	PESCHEL Julius	31 OCT 1990
4	HUN	(b)	FIALA Balazs	01 DEC 1994
		(2)	CSISZAR Peter	26 MAR 1994
		(3)	TAMAS Bence	02 JUN 1992
		(s)	KRPESICS Peter	25 SEP 1991
5	RUS	(b)	TELITCYN Maksim	28 DEC 1990
		(2)	BOGDASHIN Aleksandr	25 OCT 1994
		(3)	CHAUKIN Alexander	22 APR 1988
		(s)	VIKULIN Aleksey	10 DEC 1992
6	ITA	(b)	DUCHICH Federico	19 JUL 1993
		(2)	BARBARO Leone	20 OCT 1993
		(3)	TEDESCO Lorenzo	30 DEC 1990
		(s)	SFILIGOI Piero	03 JUN 1994

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FISA Data Service — data processing by OMEGA TIMING

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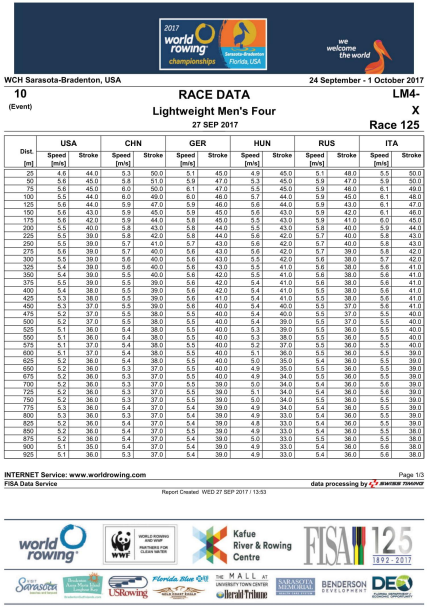
Media Start List



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WCH Sarasota-Bradenton, USA — 24 September - 1 October 2017

10 (Event) — **RACE DATA** — Lightweight Men's Four — 27 SEP 2017 — LM4- X Race 125

Dist.	USA Speed [m/s]	USA Stroke	CHN Speed [m/s]	CHN Stroke	GER Speed [m/s]	GER Stroke	HUN Speed [m/s]	HUN Stroke	RUS Speed [m/s]	RUS Stroke	ITA Speed [m/s]	ITA Stroke
25	4.6	44.0	5.3	50.0	5.1	45.0	4.9	45.0	5.1	48.0	5.5	50.0
50	5.6	45.0	5.8	51.0	5.9	47.0	5.3	45.0	5.9	47.0	5.9	50.0
75	5.6	45.0	6.0	50.0	6.1	47.0	5.5	45.0	5.9	46.0	6.1	49.0
100	5.5	44.0	6.0	49.0	6.0	46.0	5.7	44.0	5.9	45.0	6.1	48.0
125	5.6	44.0	5.9	47.0	5.9	46.0	5.6	44.0	5.9	43.0	6.1	47.0
150	5.6	43.0	5.9	45.0	5.9	45.0	5.6	43.0	5.9	42.0	6.1	46.0
175	5.6	42.0	5.9	44.0	5.8	45.0	5.5	43.0	5.8	41.0	6.0	45.0
200	5.5	40.0	5.8	43.0	5.8	44.0	5.5	43.0	5.8	40.0	5.9	44.0
225	5.5	39.0	5.8	42.0	5.8	44.0	5.6	42.0	5.7	40.0	5.8	43.0
250	5.5	39.0	5.7	41.0	5.7	43.0	5.6	42.0	5.7	40.0	5.8	43.0
275	5.6	39.0	5.7	40.0	5.6	43.0	5.6	42.0	5.7	39.0	5.8	42.0
300	5.5	39.0	5.6	40.0	5.6	43.0	5.5	42.0	5.8	38.0	5.7	42.0
325	5.4	38.0	5.6	40.0	5.6	43.0	5.5	41.0	5.8	38.0	5.6	41.0
350	5.4	39.0	5.5	40.0	5.6	42.0	5.5	41.0	5.8	38.0	5.6	41.0
375	5.5	39.0	5.5	39.0	5.6	42.0	5.4	41.0	5.6	38.0	5.6	41.0
400	5.4	38.0	5.5	39.0	5.6	42.0	5.4	41.0	5.5	38.0	5.6	41.0
425	5.3	38.0	5.5	39.0	5.6	41.0	5.4	41.0	5.5	38.0	5.6	41.0
450	5.3	37.0	5.5	39.0	5.6	40.0	5.4	40.0	5.5	37.0	5.6	41.0
475	5.2	37.0	5.5	38.0	5.5	40.0	5.4	40.0	5.5	37.0	5.5	40.0
500	5.2	37.0	5.5	38.0	5.5	40.0	5.4	39.0	5.5	37.0	5.5	40.0
525	5.1	36.0	5.4	38.0	5.5	40.0	5.3	39.0	5.5	36.0	5.5	40.0
550	5.1	36.0	5.4	38.0	5.5	40.0	5.3	38.0	5.5	36.0	5.5	40.0
575	5.1	37.0	5.4	38.0	5.5	40.0	5.2	37.0	5.5	36.0	5.5	40.0
600	5.1	37.0	5.4	38.0	5.5	40.0	5.1	36.0	5.5	36.0	5.5	39.0
625	5.2	36.0	5.4	38.0	5.5	40.0	5.0	35.0	5.4	36.0	5.5	39.0
650	5.2	36.0	5.3	37.0	5.5	40.0	4.9	35.0	5.5	36.0	5.5	39.0
675	5.2	36.0	5.3	37.0	5.5	40.0	4.9	34.0	5.5	36.0	5.5	39.0
700	5.2	36.0	5.3	37.0	5.5	39.0	5.0	34.0	5.4	36.0	5.6	39.0
725	5.2	36.0	5.3	37.0	5.5	39.0	5.1	34.0	5.4	36.0	5.6	39.0
750	5.2	36.0	5.3	37.0	5.5	39.0	5.0	34.0	5.5	36.0	5.5	39.0
775	5.3	36.0	5.4	37.0	5.4	39.0	4.9	34.0	5.4	36.0	5.5	39.0
800	5.3	36.0	5.3	37.0	5.4	39.0	4.9	33.0	5.4	36.0	5.5	39.0
825	5.2	36.0	5.4	37.0	5.4	39.0	4.8	33.0	5.4	36.0	5.5	39.0
850	5.2	36.0	5.4	37.0	5.5	39.0	4.9	33.0	5.4	36.0	5.5	38.0
875	5.2	36.0	5.4	37.0	5.4	38.0	5.0	33.0	5.5	36.0	5.5	38.0
900	5.1	35.0	5.4	37.0	5.4	39.0	4.9	33.0	5.4	36.0	5.6	38.0
925	5.1	36.0	5.3	37.0	5.4	39.0	4.9	33.0	5.4	36.0	5.6	38.0

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Race Data

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WCH Sarasota-Bradenton, USA — 24 September - 1 October 2017

10 (Event) — **Results** — Lightweight Men's Four — 27 SEP 2017 — LM4- X Race 125

World Champ/ Best:	DEN	JOERGENSEN / LARSEN / BARSOE / JOERGENSEN	Amsterdam (NED) 2014	World Champ'ships 5:43.16
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World Champion:	SUI	TRAMER / SCHUERCH / NIEPMANN / GYR	Aiguebelette (FRA) 2015	World Champ'ships 5:55.31

Rank	Lane	Ctry Code		Name	500m		1000m		1500m		2000m		Prog. Code	
1	6	ITA	(b)	DUCHICH Federico	1:28.28	(1)	2:58.20	(1)	4:29.64	(1)	**6:01.82**		FA	
			(2)	BARBARO Leone			1:29.92	(1)	1:31.44	(1)	**1:32.18**	(1)		
			(3)	TEDESCO Lorenzo										
			(s)	SFILIGOI Piero										
2	5	RUS	(b)	TELITCYN Maksim	1:29.97	(4)	3:01.10	(2)	4:33.59	(2)	**6:07.05**		FA	
			(2)	BOGDASHIN Aleksandr			1:31.13	(2)	1:32.49	(2)	**1:33.46**	(2)		
			(3)	CHAUKIN Alexander	1.69		2.90		3.95		**5.23**			
			(s)	VIKULIN Aleksey										
3	3	GER	(b)	STOECKER Patrik	1:29.49	(2)	3:01.44	(3)	4:35.06	(3)	**6:09.27**		FA	
			(2)	KESSLER Sven			1:31.95	(3)	1:33.62	(3)	**1:34.21**	(3)		
			(3)	KOCH Jonathan	1.21		3.24		5.42		**7.45**			
			(s)	PESCHEL Julius										
4	2	CHN	(b)	LI Xiaoxiong	1:29.66	(3)	3:02.48	(4)	4:36.62	(4)	**6:10.95**		FA	
			(2)	WANG Tiexin			1:32.82	(4)	1:34.14	(4)	**1:34.33**	(4)		
			(3)	YU Chenggang	1.38		4.28		6.98		**9.13**			
			(s)	ZHAO Jinglin										
5	1	USA	(b)	FOSTER Thomas	1:34.63	(6)	3:11.11	(5)	4:47.90	(5)	**6:26.63**		FA	
			(2)	DAWE Nicholas			1:36.48	(5)	1:36.79	(5)	**1:38.73**	(5)		
			(3)	SMITH David	6.35		12.91		18.28		**24.81**			
			(s)	NEILS Andrew										
6	4	HUN	(b)	FIALA Balazs	1:33.15	(5)	3:13.56	(6)	4:59.55	(6)	**6:46.17**		FA	
			(2)	CSISZAR Peter			1:40.41	(6)	1:45.99	(6)	**1:46.62**	(6)		
			(3)	TAMAS Bence	4.87		15.36		29.91		**44.35**			
			(s)	KRPESICS Peter										

Progression System: Remaining Crews to Final A (1...->FA)

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Results

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Data: 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

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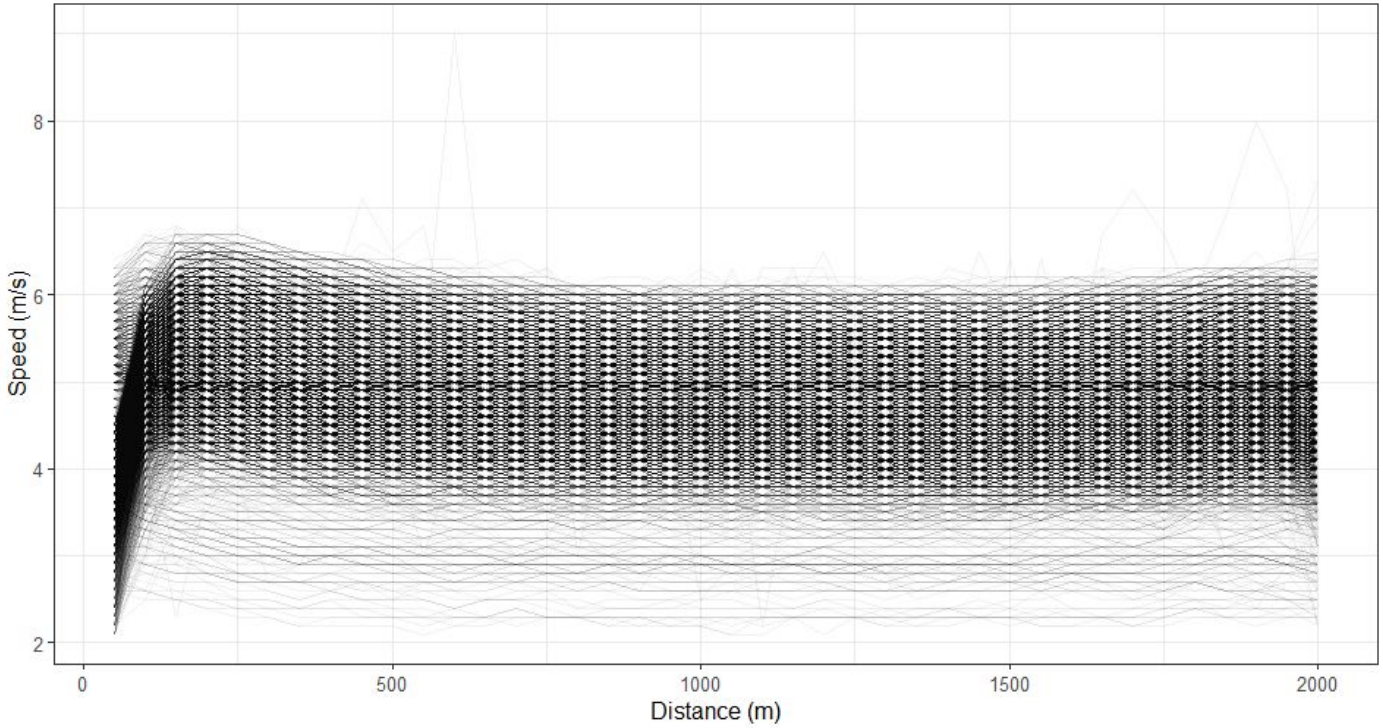
Goals!

- 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:
  - Magnitudes of average speed depend on factors such as boat size, weight class, age group and gender
  - Longitudinal data

Raw Speed Curves



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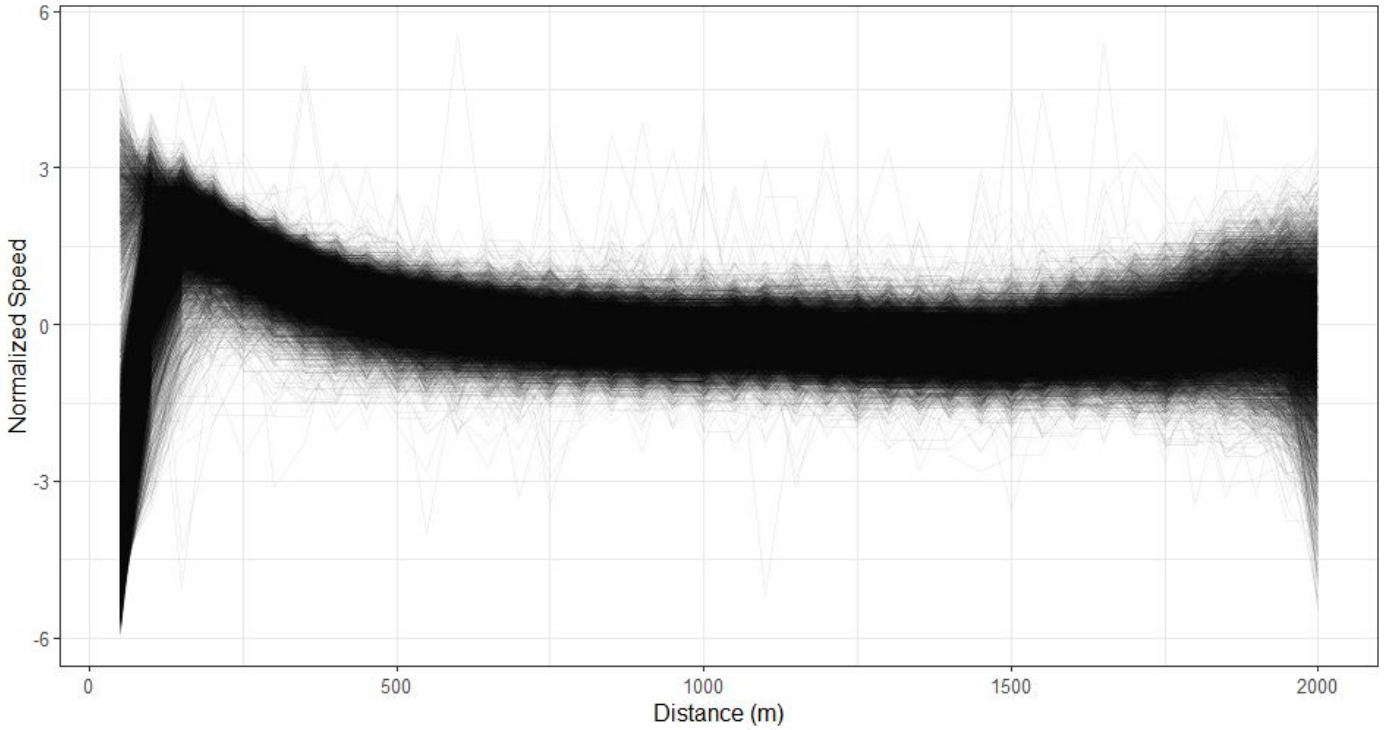
Normalized Speed Curves



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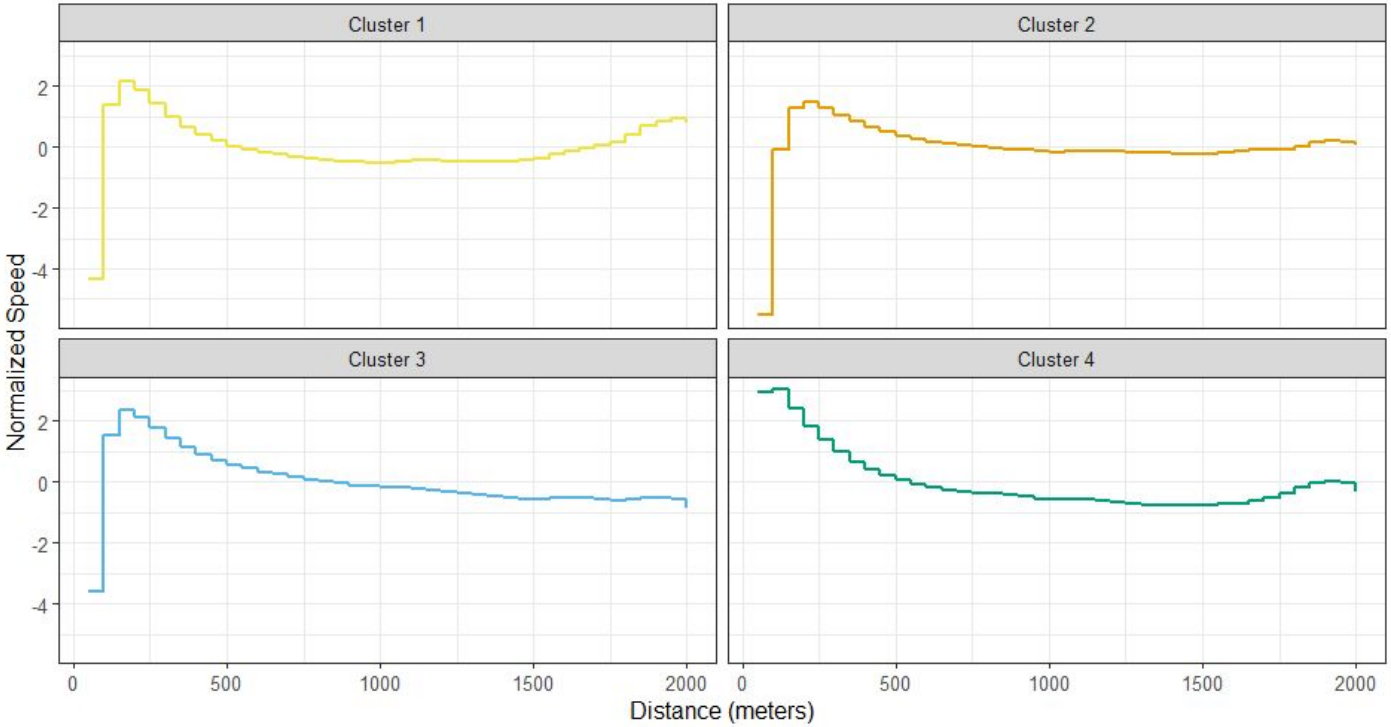
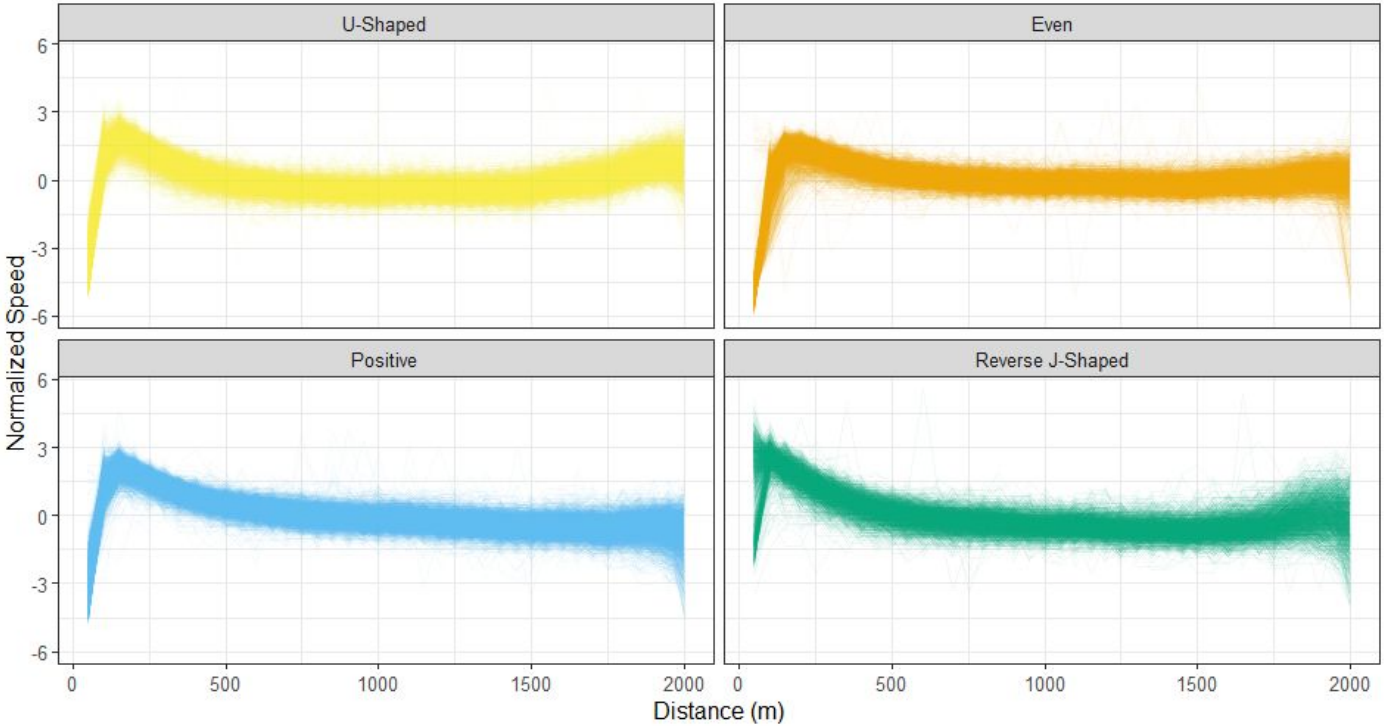
k-Shape Clustering

- Iterative process to minimize distance for an observation to a cluster centroid
- Uses Shape-based distance (SBD) (Paparrizos and Gravano 2016) 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

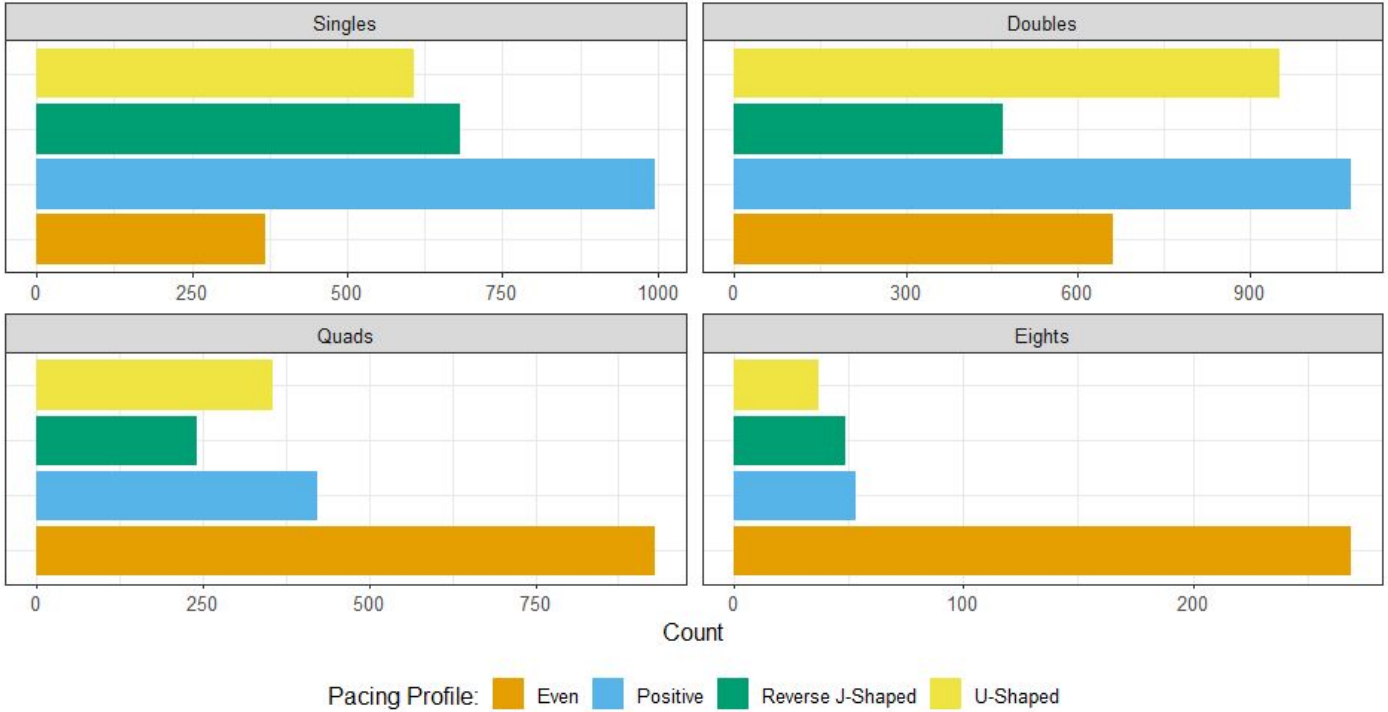
Cluster Centroids



Pacing Profiles



Boat Sizes


Singles
Doubles
Quads
Eights
0
250
500
750
1000
0
300
600
900
0
250
500
750
0
100
200
Count
Pacing Profile:
Even
Positive
Reverse J-Shaped
U-Shaped

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

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Model Results

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

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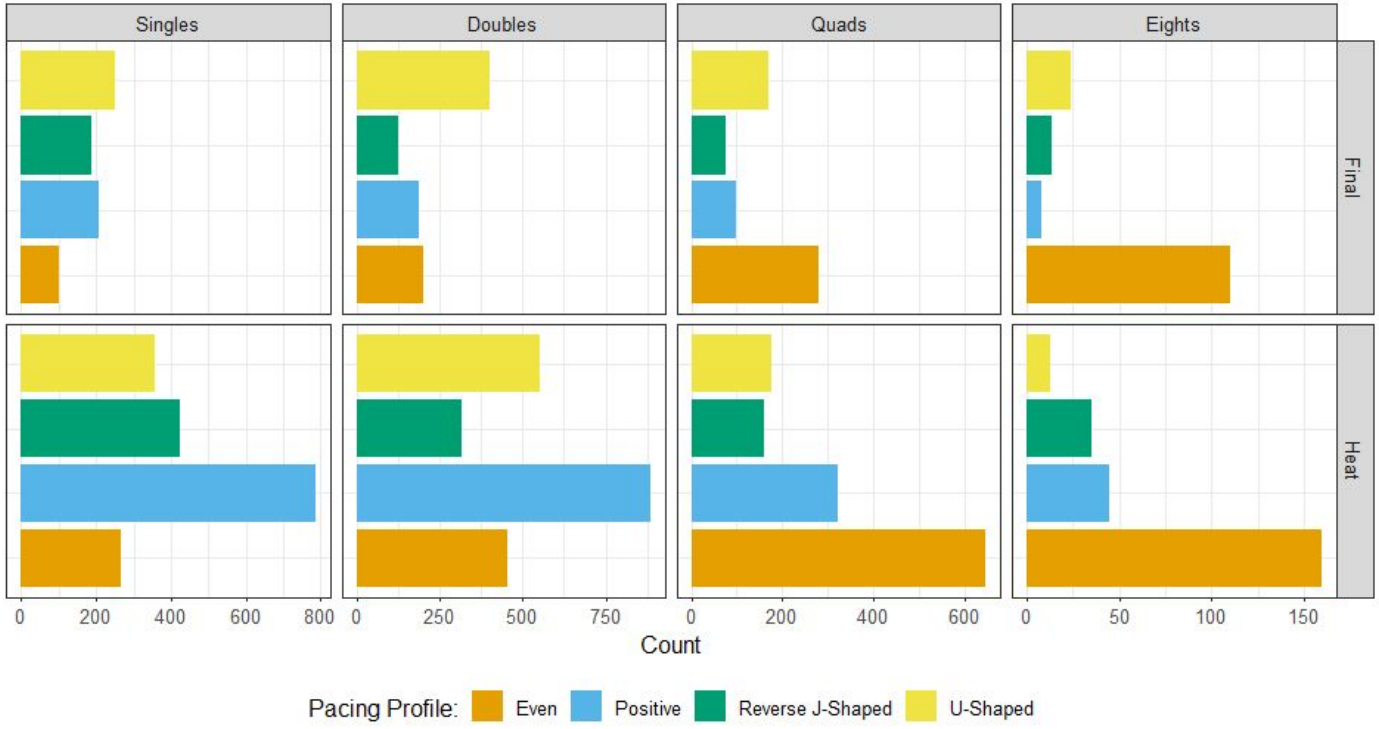
Boat Sizes and Heat/Final



Boat Sizes, Heat/Final and Placement

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

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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
- I'd love your feedback and thoughts!

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THANKS!

Any Questions?

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References

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