FORCE DEVELOPMENT IN & OUT OF THE WATER

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Looking at force measurements in the water with SmartPaddles (untethered swimming) is a relatively new thing.
It is one more tool for the coaches' tool box that can add more insight into swimmers' potential for improvement.
It is another piece of the swimming puzzle, and this presentation is about a study of force measurements on land and in the water, in a way that it has not been looked at before

Background story

The idea or notion of there being a difference, or a connection, between how much force one can produce on land vs how much can be carried into the actual swimming, came about already when I was a competitive swimmer

Fast forward to my coaching career, and I have seen countless swimmers be great at dryland strength but not being able to use that strength in the water, and vice versa.

Through connections with coaches and innovators (through social media actually) this study came to be. Rob Sleamaker, CEO of Vasa connected me with coach Jack Fabian, and I had a connection with Ari Auvinen of Trainesense. This study came about with the help of these individuals.

Does force development on land correspond to force development in the water?

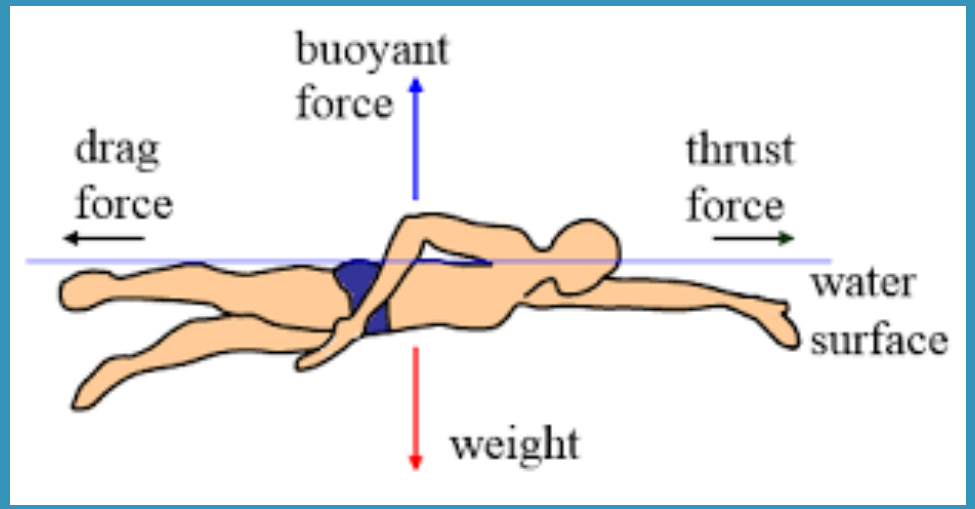
- Is there a correlation between being able to generate a lot of force or power on land (against a surface), and the ability to produce force or power in the water? Will improving power on land automatically mean an improvement in the water?
- Does higher force development correlate to faster swimming velocity?
- Existing studies use tethered swims, this is a look at ”free swim” measurements
- Being able to measure both in the water and on land makes it possible to tailor and monitor a training plan to improve force development and symmetry of the stroke

The study – why?

- If a swimmer can increase propulsive force (at constant drag/resistance) then swim velocity should increase.
- SmartPaddles can provide insight to what happens to stroke/technique when fatigued and force development decrease. Connecting the data with video analysis provides a powerful combination to a larger picture of the swimmer's stroke and where and why it falls apart at fatigue.
- Is a decrease in velocity due to decrease in force development, or due to an increase in resistance (surface area)? If it is due to increase in resistance then the same drop in force/power should not be seen on land.
- VASA SwimErg mimics the pull phase in swimming and can be used to train proper pull phase mechanics at the fatigued state, to improve force development in the swim once the swimmer becomes fatigued.

FORCE vs POWER

$$F_D = \frac{1}{2}\rho A C_D v^2$$



- Challenge:
  - *SmartPaddles measure Force and Impulse*
  - *VASA SwimErg measures Power.*
- Force = Mass x Acceleration, or in the water a little more complex
  - *If other factors like resistance, drag and water density remain constant between swims then increasing force should result in an increase in swim velocity*
- Impulse = Force x Time
- Power = (Propulsive force x Distance)/Time = Propulsive force x Velocity, therefore propulsive force correlates to power
  - *Δ relative force vs Δ relative power once the swimmer fatigues will give an indication of where the swimmer has potential to improve*

The study - Methods

- 3 swimmers (2 male, 1 female)
- VASA SwimErg, with ANT+ ™ Wireless Power Meter connected to TrainerRoad program. Stroke rate is monitored by the TrainerRoad program.
- Swim with SmartPaddles and Pull Buoy (to take out the effect of kicking) in 25-yard pool at Keene State College. Stroke rate is set by using FINIS Tempo trainer.
- Protocol for testing
  - *6x90 seconds on VASA SwimErg @3:00*
  - *6x150 yards freestyle (125 yards for female swimmer) @3:00*
  - *Goal to maintain stroke rate per effort @ 40 / 43 / 46 / 49 / 52 / 55 SPM respectively (increase in stroke rate per effort was a way of controlling each effort on land and in the water for better comparison)*
  - *Vasa SwimErg measurements were done first, followed by SmartPaddle measurements, with a recovery period in between including easy swimming (both test conducted the same day for each athlete)*

Trainesense SmartPaddles

SmartPaddles provide force data in three directions – 1) Lateral sideways, 2) Vertical and 3) Lateral propulsive

> *Propulsive force is the force that generates swimming speed forward*

SmartPaddles can be used for all strokes

A great tool to be able to get the objective data for both arms/hands (compared to an overall measurement of a tethered swim), that can show any asymmetries in the stroke technique that the eye might not catch

An advantage to force measurements with SmartPaddles is the ease of use and untethered swimming

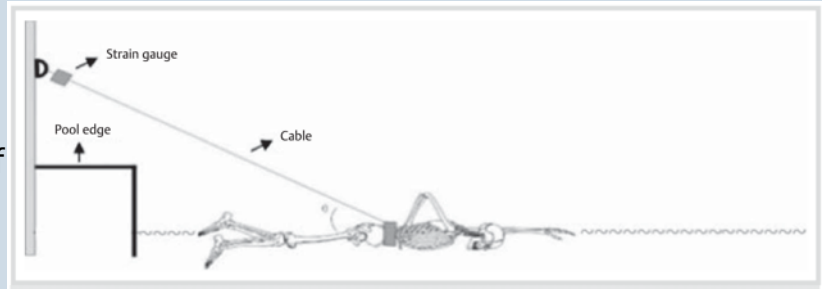
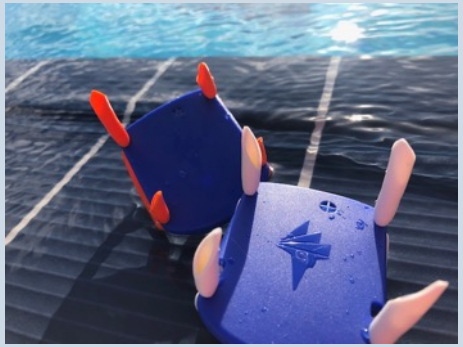
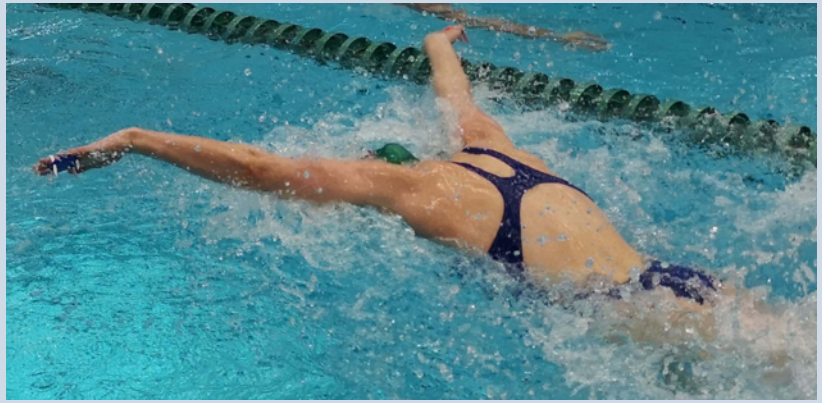
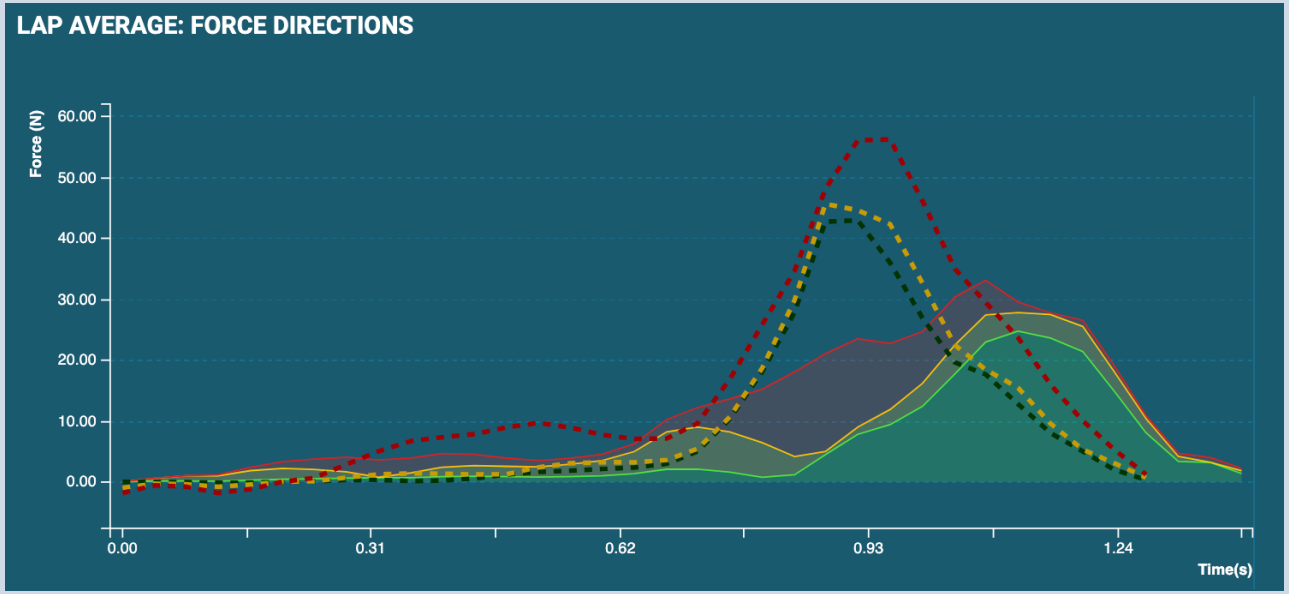


Image: K.B. Santos et al, International Journal of Sport Medicine 2013







VASA SwimErg

The Vasa Swim Ergometer is a swim bench for improving endurance, sustained power and stroke technique

Allows for technique improvements by having instant feedback from the real time data, and the coach at the same time

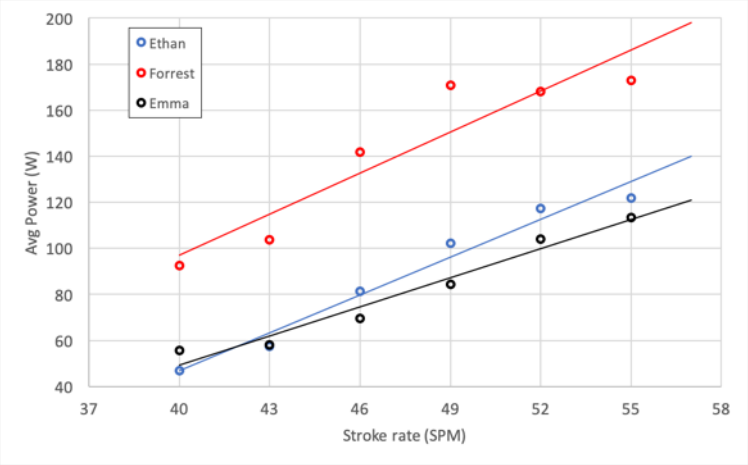
Dryland training that is very specific for swimming – mimics pull phase = propulsive force/power

Great substitute for pool swimming if a swimmer is injured or otherwise can not be in the water

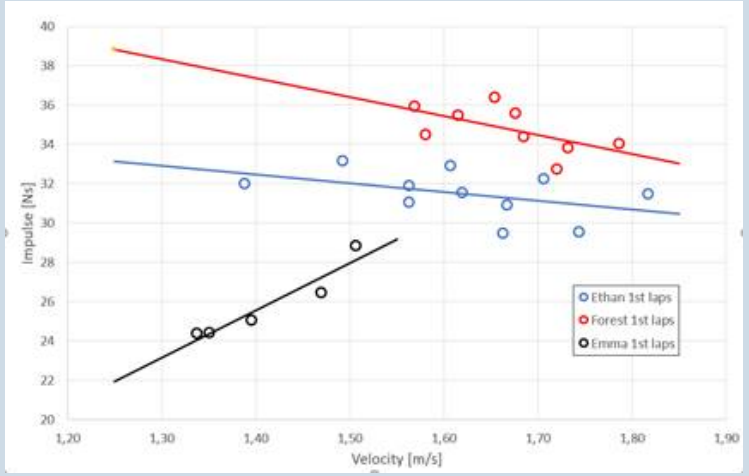
VASA SwimErg equipped with an ANT+ ™ Wireless Power Meter provides real-time data on the LCD screen, and can be connected to TrainerRoad training program to record and monitor data output on a larger screen

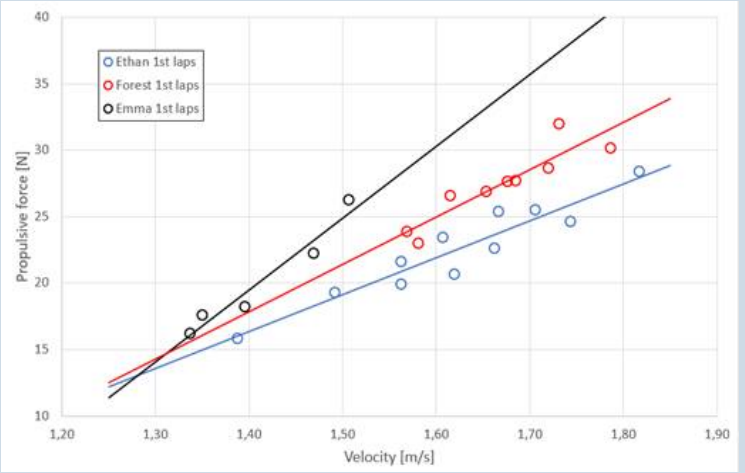
Findings – for these 3 swimmers

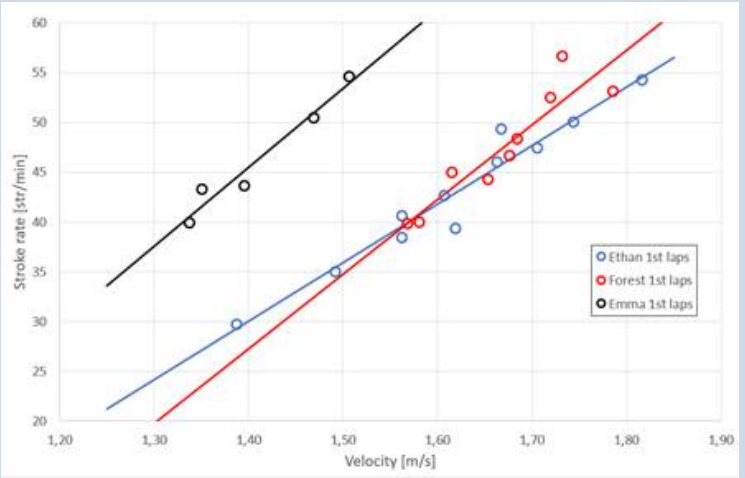
- ***Is there a correlation between being able to generate a lot of force or power on land (against a surface), and the ability to produce force or power in the water?*** For these 3 swimmers yes

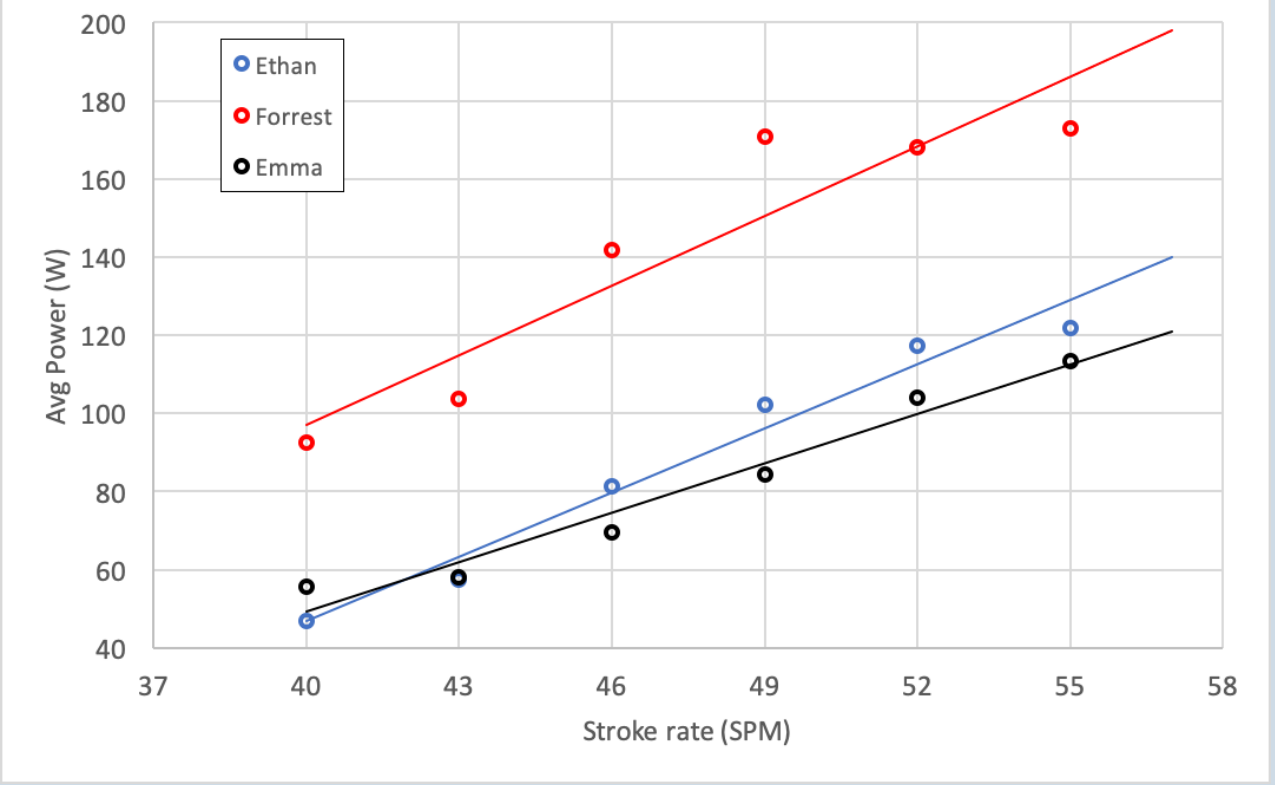


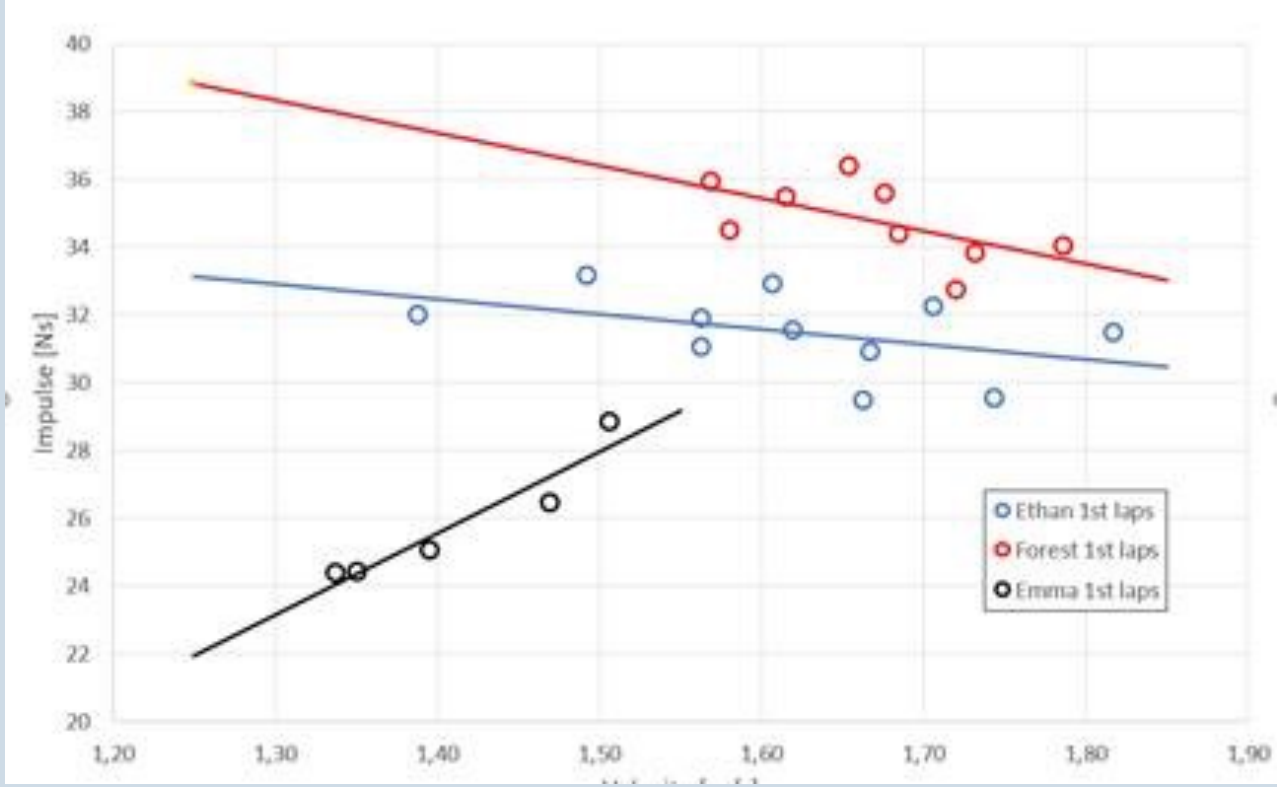
- ***Does higher force development correlate to faster swimming velocity?*** For these 3 swimmers yes





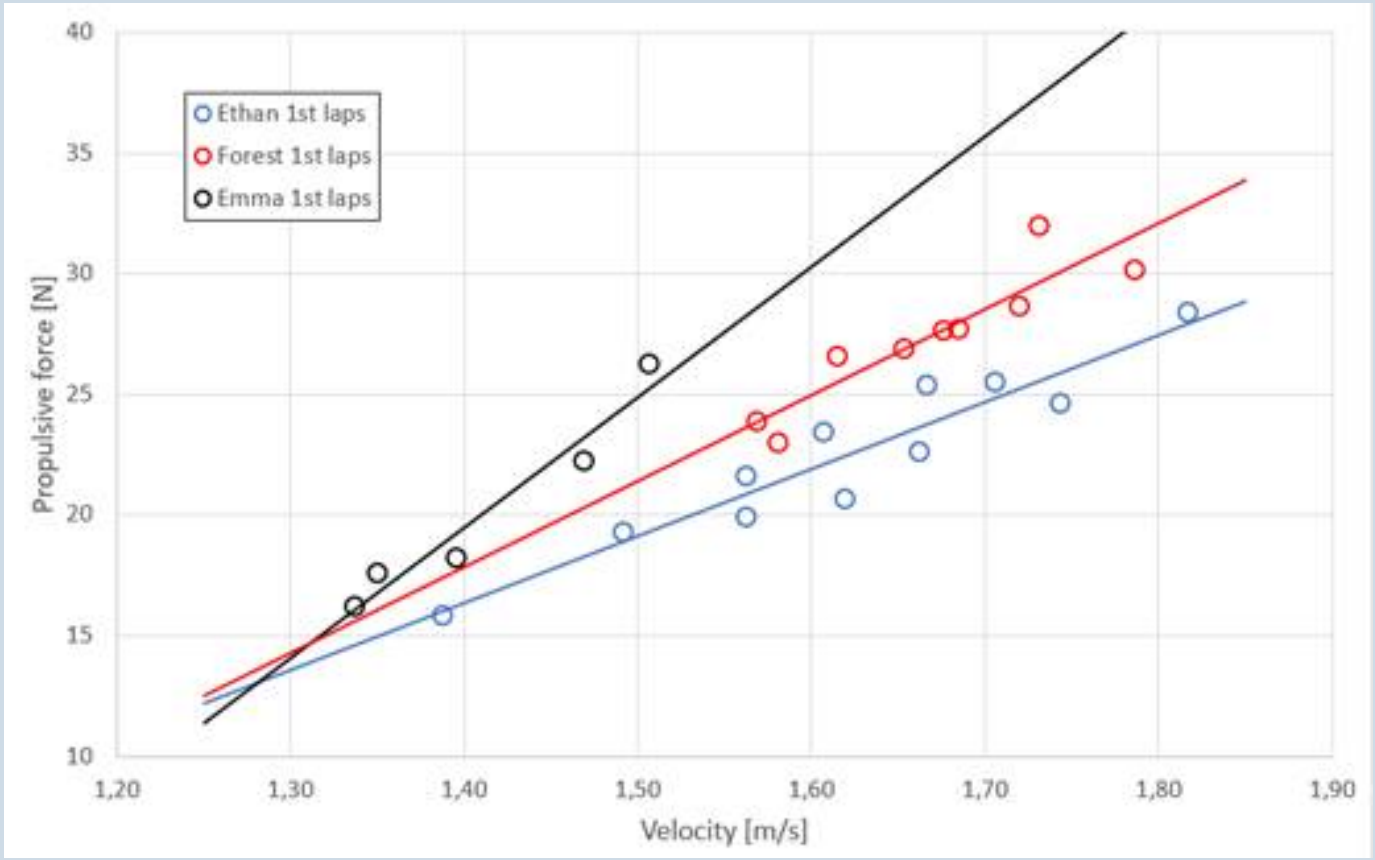


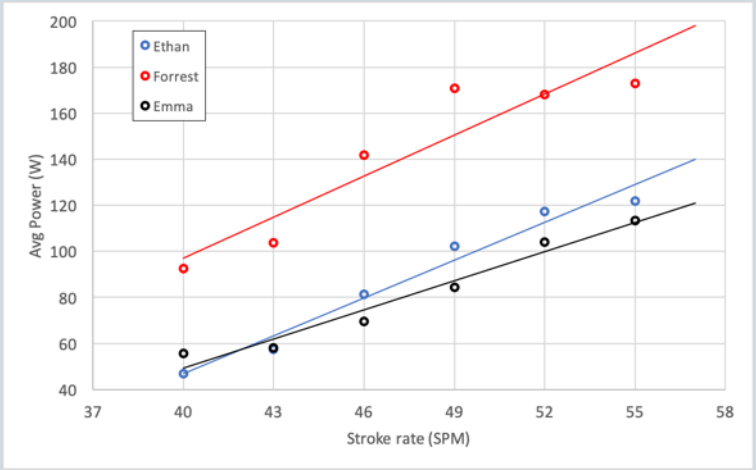




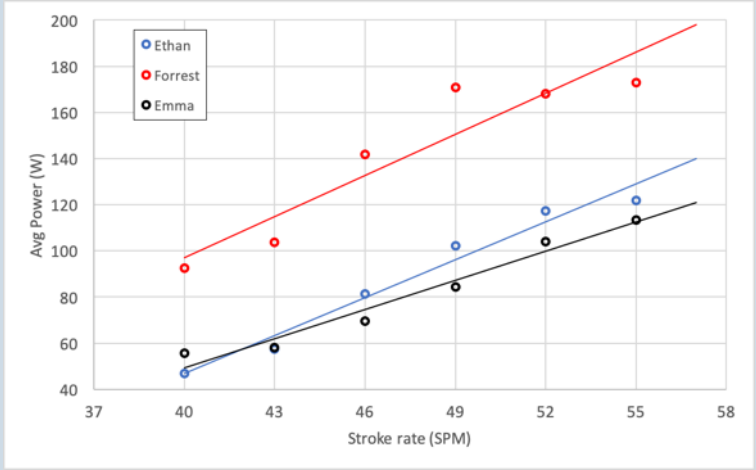
- Swimmers that can generate high power on dryland (Vasa) seem to be able to generate high impulse (SmartPaddles) e.g. Forrest

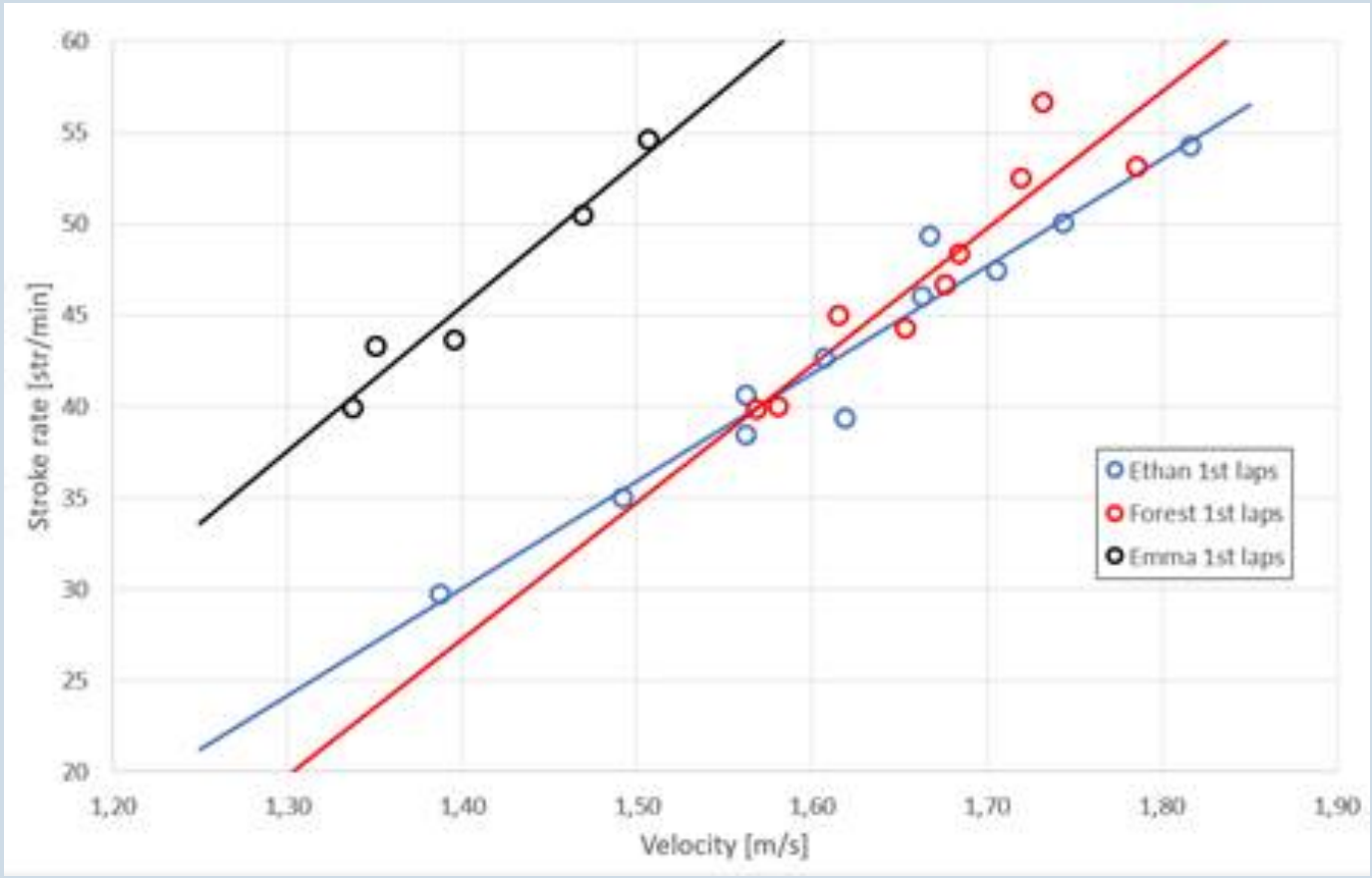
- Lower force at a given speed indicates lower resistance, e.g. Ethan as he needs lowest propulsive force for a given speed, and not as big of increase in force in order to increase speed





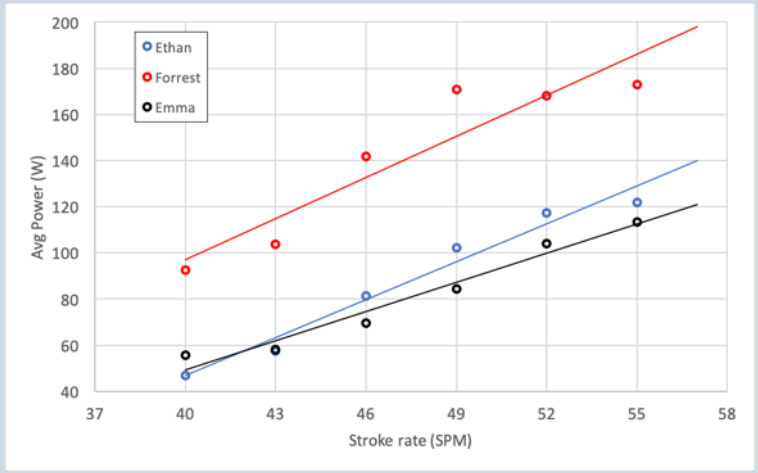
- Combined effect seen in stroke rate e.g. Emma has both low impulse and higher resistance, which means her stroke rate is much higher than the boys at the same speed
- The inverse relationship is seen with stroke length



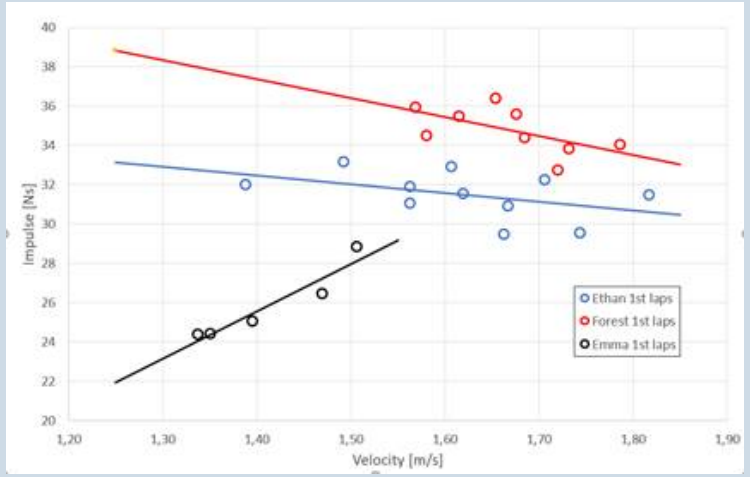


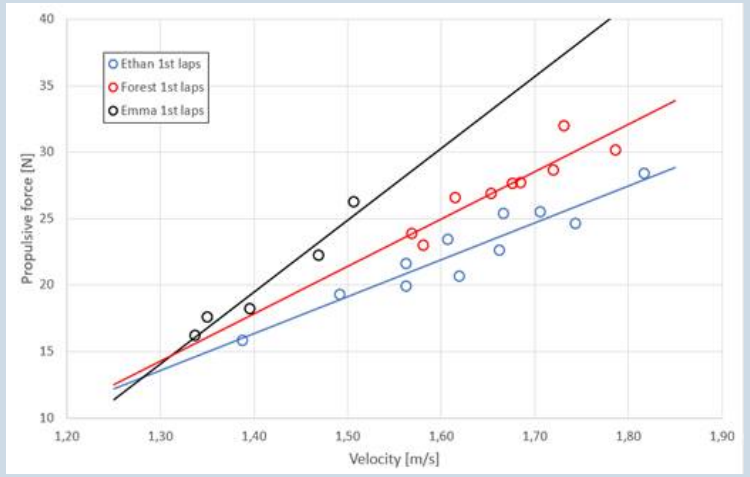
Findings – for these 3 swimmers

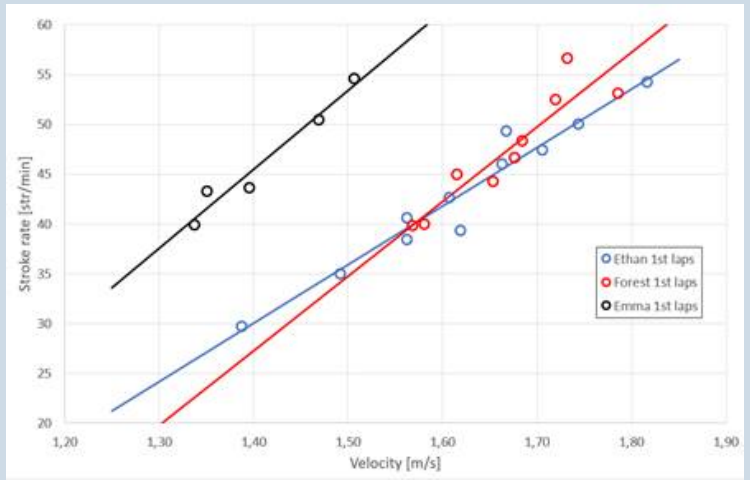
- Swimmers that can generate high power on dryland seem to be able to generate high impulse e.g. Forrest



- Lower force at a given speed indicates lower resistance, e.g. Ethan
- Combined effect seen in stroke rate e.g. Emma has both low impulse and higher resistance, which means her stroke rate is much higher than the boys at the same speed
- *VASA SwimErg can measure if the swimmer has the strength required, and SmartPaddles can verify if the swimmer is able to apply that strength in the water*

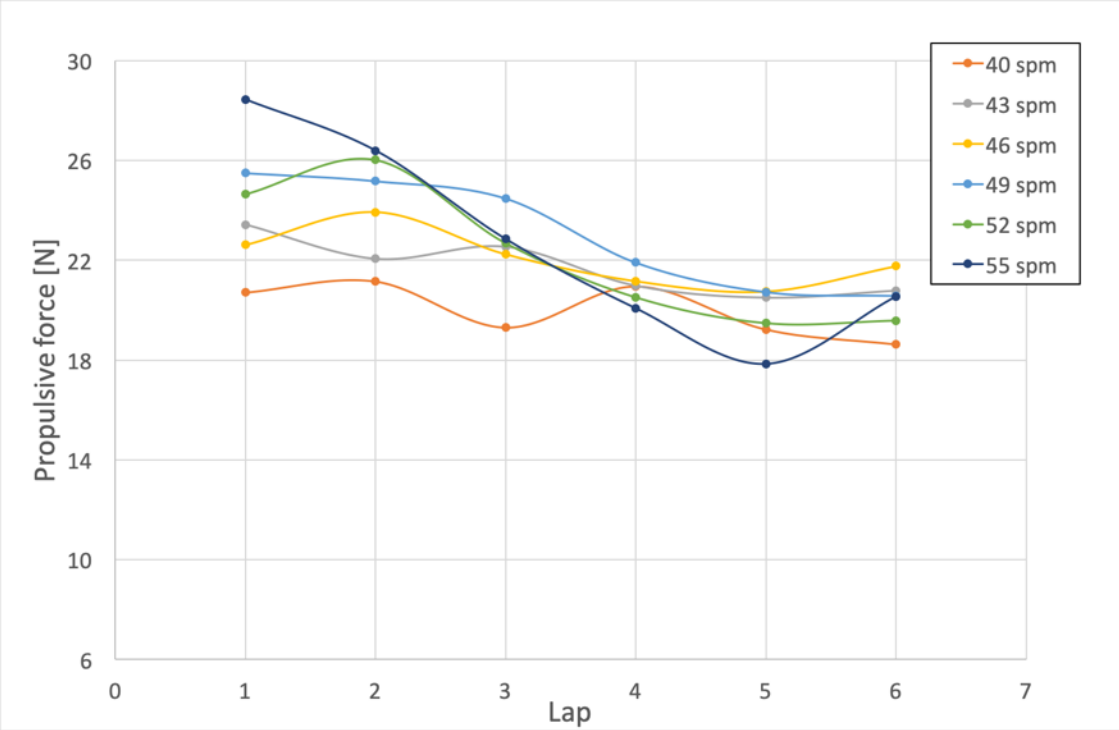






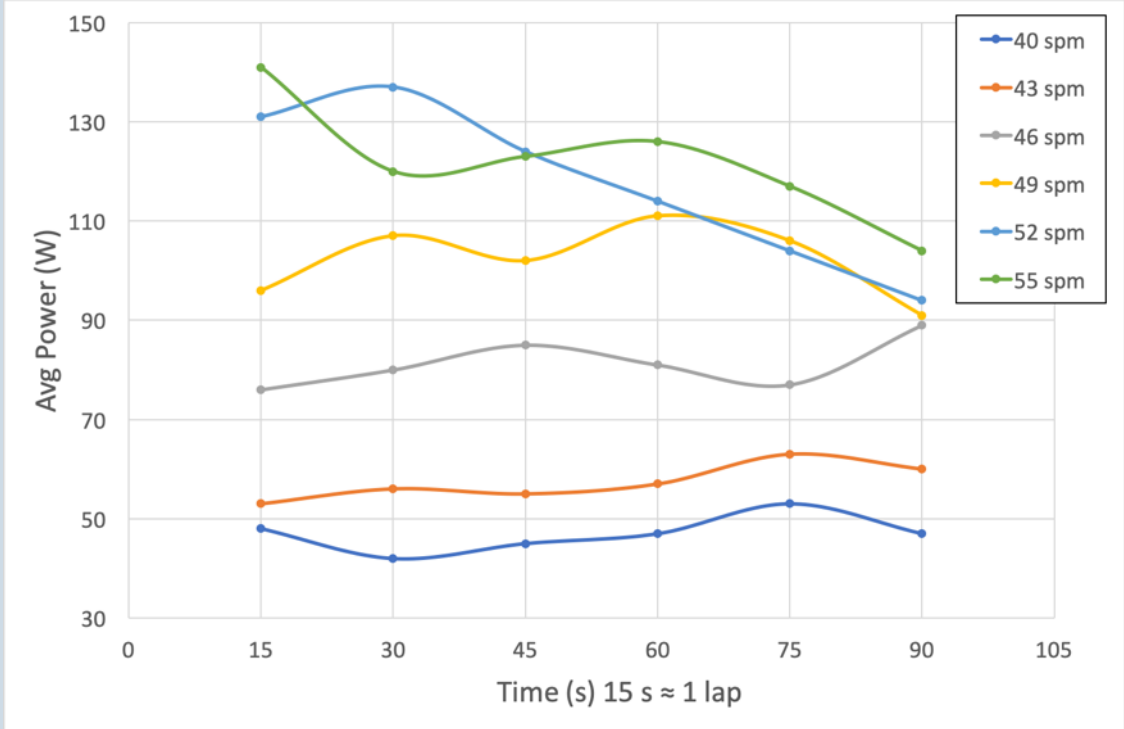
Findings – force & power

SmartPaddle



150 @SPM	Drop in force (N) lap 5	lap 6
40 spm	-7%	-10%
43 spm	-12%	-11%
46 spm	-8%	-4%
49 spm	-19%	-19%
52 spm	-21%	-21%
55 spm	-37%	-28%

Vasa SwimErg



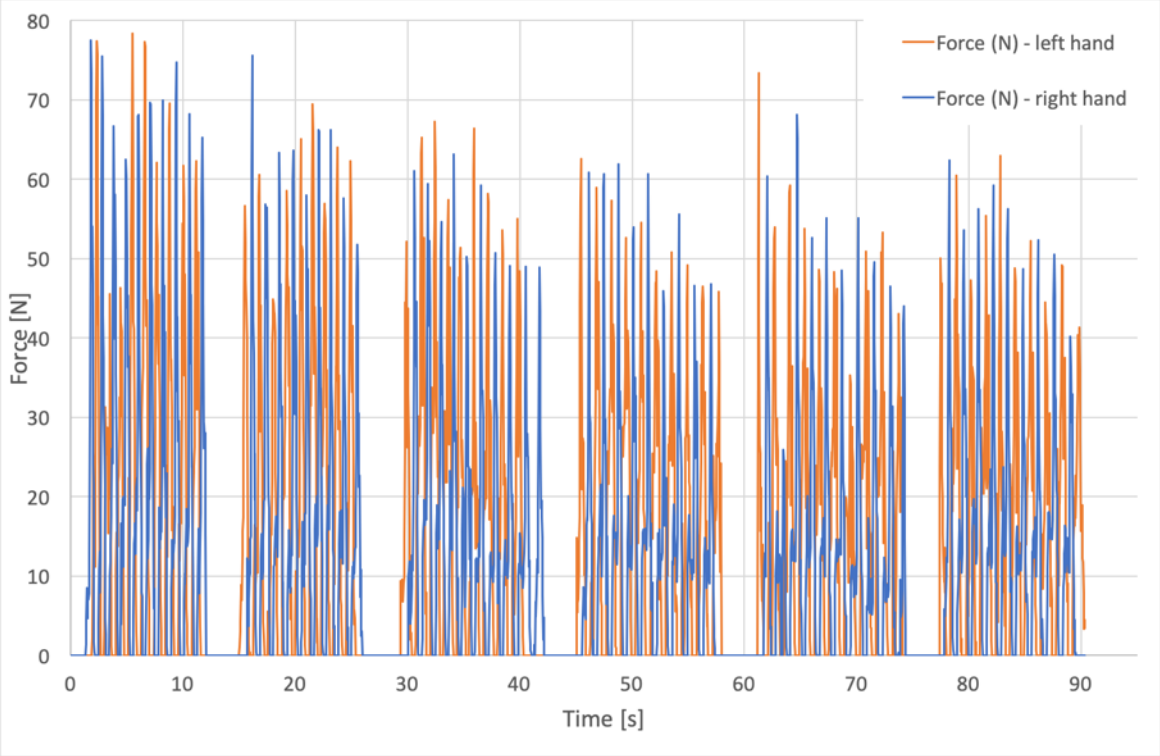
150 @SPM	Drop in Power (W) lap 5	lap 6
40 spm	10%	-2%
43 spm	19%	13%
46 spm	1%	17%
49 spm	10%	-5%
52 spm	-21%	-28%
55 spm	-17%	-26%

Similar magnitude in drop in force (SmartPaddle) and drop in power (VASA) once swimmer fatigues

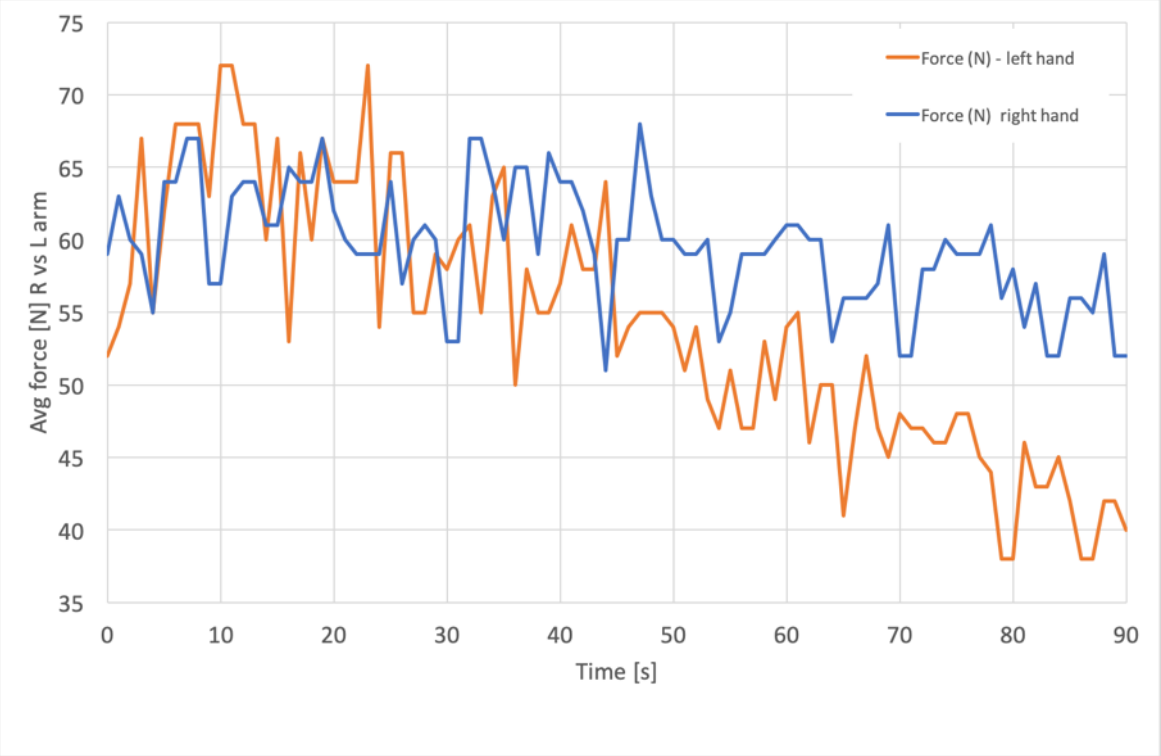
Improvement on land should correlate to improvement in the water

Findings - Right arm vs Left arm

SmartPaddle



Vasa SwimErg



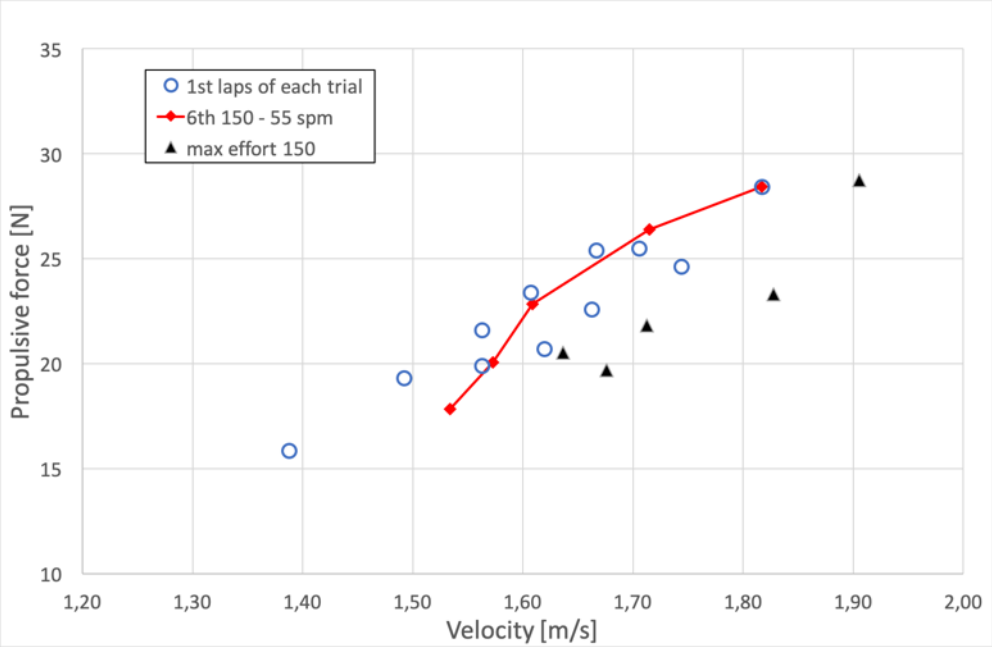
Different time stamps for SmartPaddle force measurements compared to VASA SwimErg ANT+ measurements

Closer look at the data → LEFT arm has a greater drop in force when fatigued than the RIGHT arm, both on land and in the water

This needs to be looked at more closely in a follow up study

	Max Force (N) lap 1	Min Force (N) lap 5	% Drop in Force
SmartPaddle			
LEFT	78	35	-55%
RIGHT	77	43	-44%
VASA SwimErg			
LEFT	72	38	-47%
RIGHT	67	52	-22%

Findings – Force vs Velocity



Fairly linear relationship between propulsive force and velocity

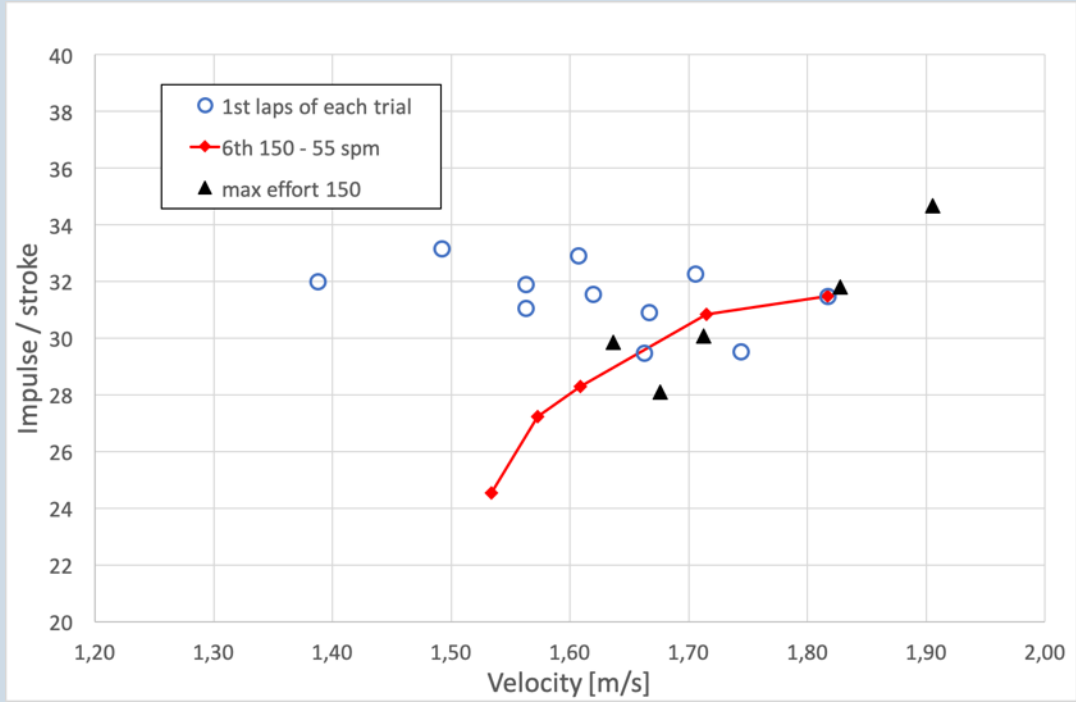
Significant drop in force and velocity throughout fastest swim as the swimmer fatigues – follows the linear relationship

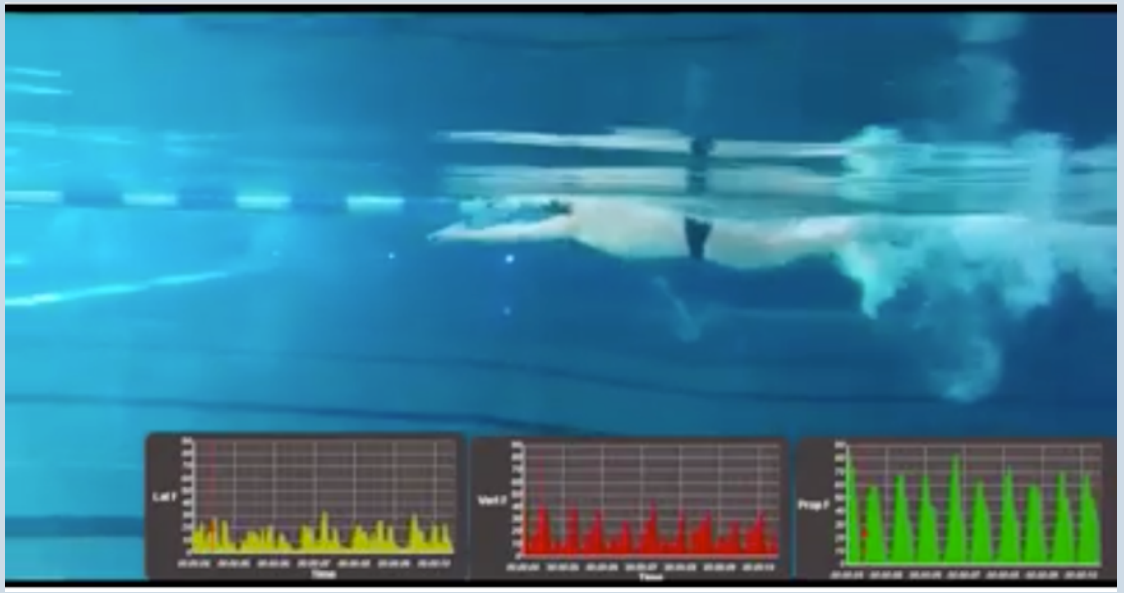
As stroke rate increase – stroke length decrease – shorter time per stroke – force decrease – impulse per stroke decrease = work on maintaining stroke length and force per stroke when fatigue

Initial impulse per stroke is very similar even if stroke rate and velocity is different for each swim

Once swimmer fatigues throughout fast swim impulse per stroke decreases significantly

Interesting at max effort (with kicking) impulse per stroke is higher initially, and drop is not as steep. Coupling motions? Body position? Lactate fatigue different?





Application

- Dryland programs that targets a specific need of the athlete. Dryland and swim program that work in conjunction to maximize potential of the swimmer
- A way to monitor that dryland program actually provides the desired effect
- A way to improve technique both on land and in the water, to be more efficient and generate more force/power
- To address asymmetry in force generation by proper dryland and in the water

Next steps

In depth look at Right vs Left arm stroke technique asymmetries

Can dryland training facilitate learning symmetrical swimming?

More extensive look at data on various levels of swimmers

Different needs at different levels

Develop products to more easily monitor progress in force development and technique efficiency

Force vs lactate studies
Force vs heart rate studies

What causes a change in technique in a fatigued state?

Detraining study

How ability to generate force change during off season? Can this ability be maintained by a dryland program in off season?

CONTACT // MORE INFO

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