Targets

- The study was done in co-operation with Finnish Swimming Federation
- Target was to provide answers to question “what makes strokelength”
- Results are formulated in a way that they provide concrete things for the coaches on their everyday work

Test protocol

- Measurement
  - Swimmers are members of Finnish national team
  - They swam 50m @ 100m racepace
  - For the 2nd lap body speed was tracked from video and forward directing force was measured with SmartPaddle
- Analysis
  - Data was synchronized by aligning the start time and sampling frequencies
  - The correlation and the time difference between the force and speed were calculated
  - A more detailed study was carried out about the influence of force variation on body speed

Results (freestyle)

- Intracycle velocity variation (IVV) was 20% of the average velocity (14-26%, 0.14-0.52m/s)
- The forward directing force was the biggest single contributor for IVV
  - Changes in the force level are immediately visible in the velocity (~0.11sec)
  - The other contributors were temporary drag from spreading legs, breathing, slow hand deep in the water, etc.
- The variation in the velocity will always happen as swimmer is not able to maintain constant force over the whole cycle
  - The slowest point in the cycle is during the recovery phase when there is a gap in the forward force
- Stroke length is explained by
  1. Duration of the slow phase of the previous cycle (R2=0.74, rmse=18%)
  2. Maximum speed during the cycle (R2=0.22, rmse=7%)
- The observations on the impact of the force profile in the velocity
  - The peak velocity in the end of the cycle was optimized with steadily increasing forward directing force
  - Minimizing the droppage in the velocity does not require huge force in the beginning of the stroke. More important is to
    - minimize the drag from entering hand
    - start quickly the increasing forward force production

Creating continuity in force

- In practice the findings mean that the target is to create continuity in force
  - Minimise the hand action to create steadily increasing force -> force from the core
  - Stay on the previous hand as long as you are able to increase the forward directing force
  - Do a controlled rotation which enables starting the increasing force production as soon as the hand enters the water
- Typical mistakes
  - Dropping shoulder in start -> drag & lost potential
  - Too fast insweep -> too focused to build continuation
  - Push in the end -> does not increase the body speed and locks the shoulders
- There is no one single way for executing an optimal stroke
  - The correct way is to try out and learn for the trial
  - Focus on early&late phases of the stroke: we a naturally good on controlling things in visible area in the middle
- Before trying to modify the stroke in the water, the limitations in the movement control should be identified
- Capability to utilize the whole range of movement in shoulder
  - https://m.youtube.com/watch?v=o47GYJtu-C0
  - 2-3kg weight, hand extended in front, rolling from stomach to back keeping palm pointing upward
  - Lat pull-ups in pool: keep upper/fore arm on the edge of the pool and move up&down
- Increasing forward force
  - Lay on back on top of big gym ball and throw 2-3kg gym ball backwards to a target 5/10/15m away
  - Stand up and bend over and throw 2-3kg gym ball backwards to a target 5/10/15m away
- SmartPaddle measurements help on
  - Identifying the phase and nature of the limitations
  - Motivating and making swimmer more self-organized on fixing the identified issues
  - Monitor that the targeted changes happen
  - Analyse the impact of the change
  - Monitor how stable the change is over different swimming speeds and distances

The next study !

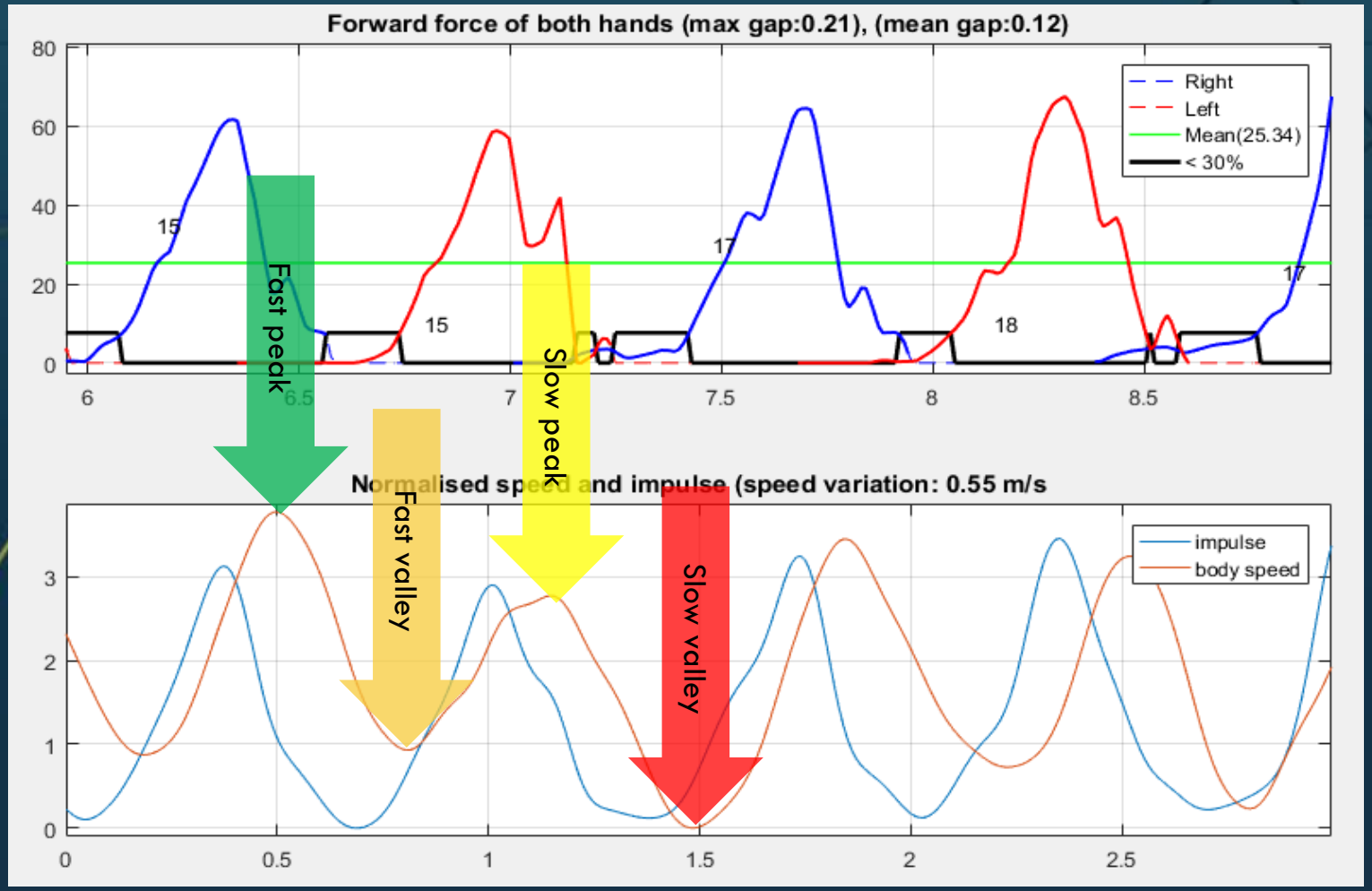
- During the review process the next study item was identified: what is the most efficient way of controlling the swimming speed

- The related questions
  - What happens in speed-up to force profile, gaps, mean force and peak force ?
  - Should only the length of force gaps be variated and keep the force profile consistently the same
  - If the force profile is changes in speed-up, how it should be changed
  - When should the maximum force level be increased ?
  - … and ultimately: what makes the sweet spot from efficiency point of view

Example1:

Biggest intracycle velocity variation biggest dependency to force

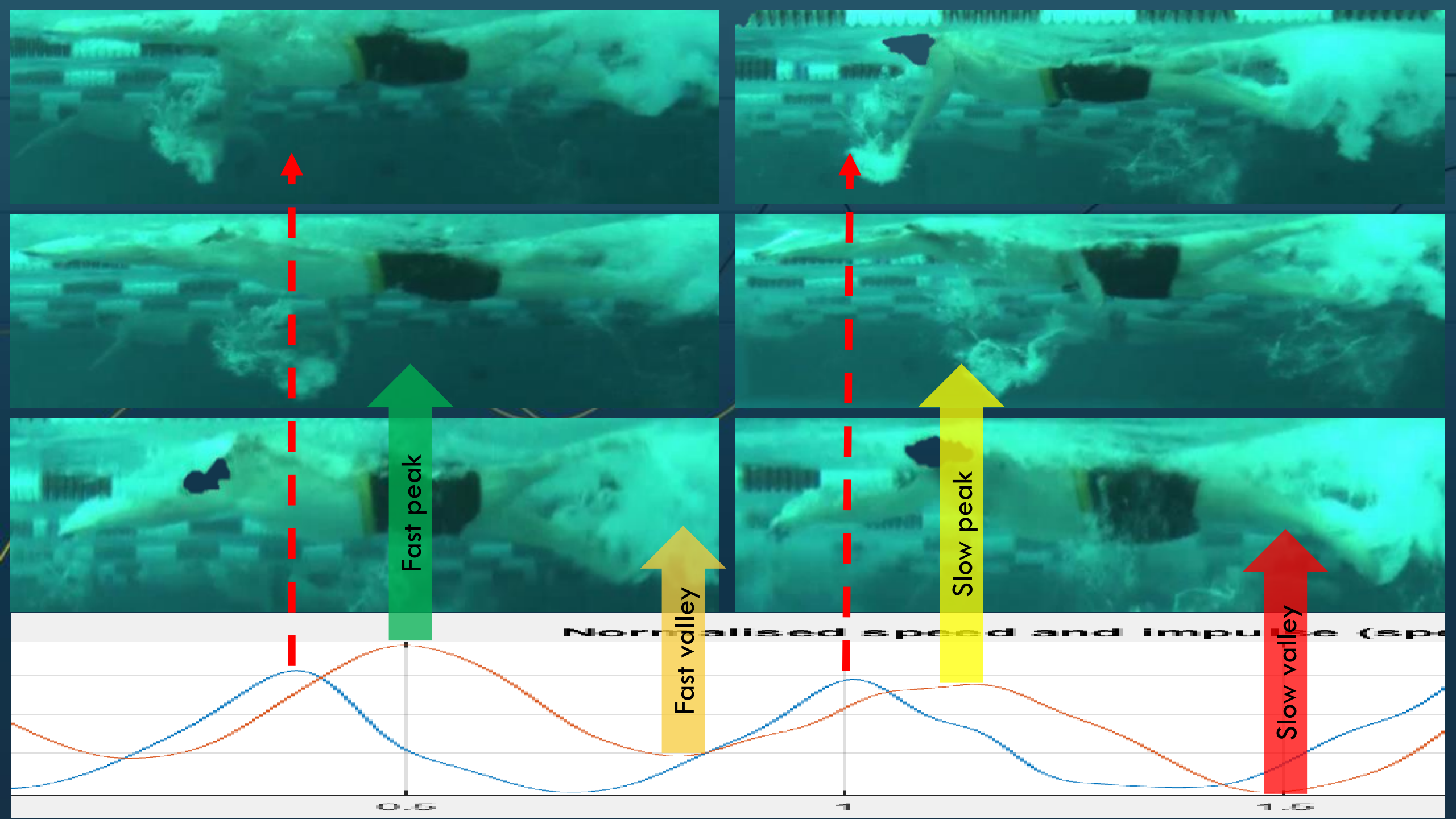
Body speed vs forward force

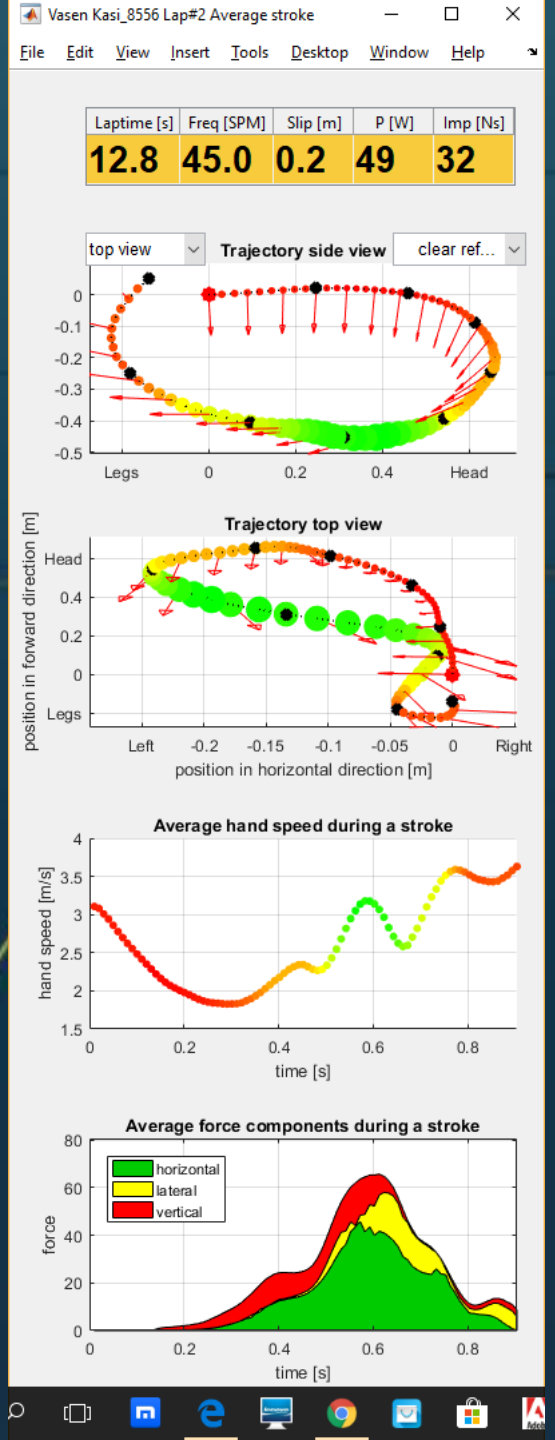


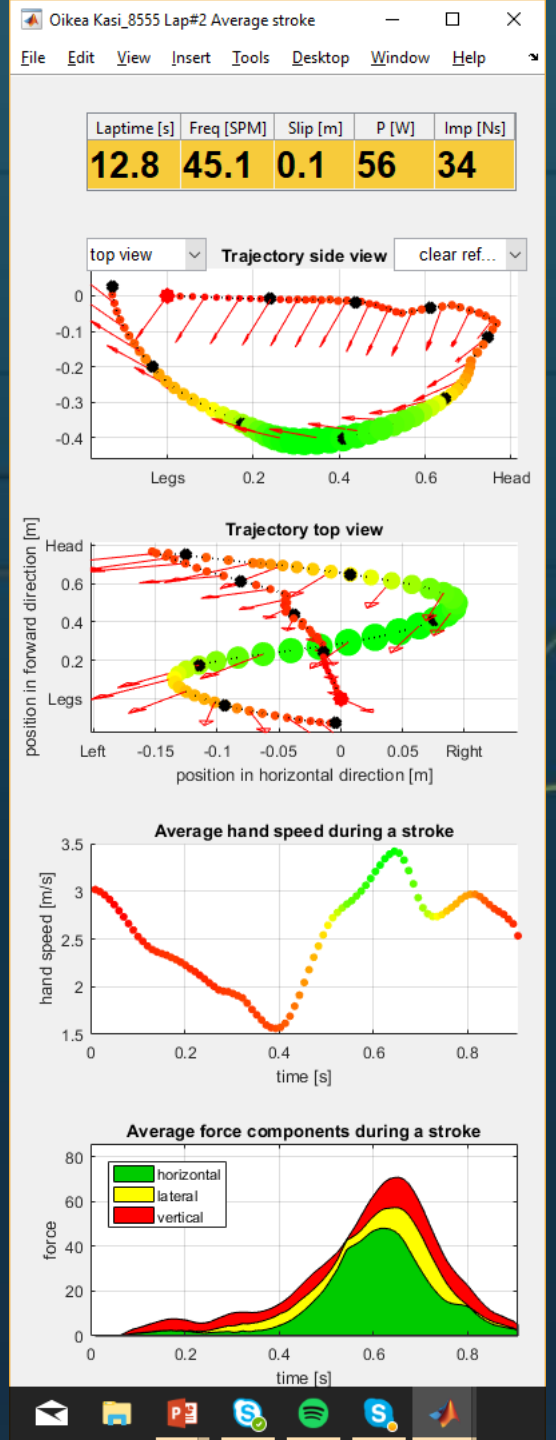
Big correlation is explained by minimum variation of drag from the body&legs

Big variation is explained by high peaks in the middle and drag from hands in entry

- Steadily increasing force on the right hand creates the highest peak
- Slowest moment is when the right hand has been in the water already for 0.4 second and is 15cm deep


Fast peak
Fast valley
Slow peak
Slow valley
0.5
1
1.5





Additional information on SmartPaddle single stroke view

Intactness of force profile

- Right hand
  - Core activation is visible in trajectory: steady speed increase and palm moves out&in and up&down
    -> both Lats and Pecs working
- Left hand
  - Bumps in the speed curve indicate disconnections in the kinetic chain
  - Trajectory shows that the biggest force is generated inwards on same depth
    -> only Pecs&arm working

Force gaps

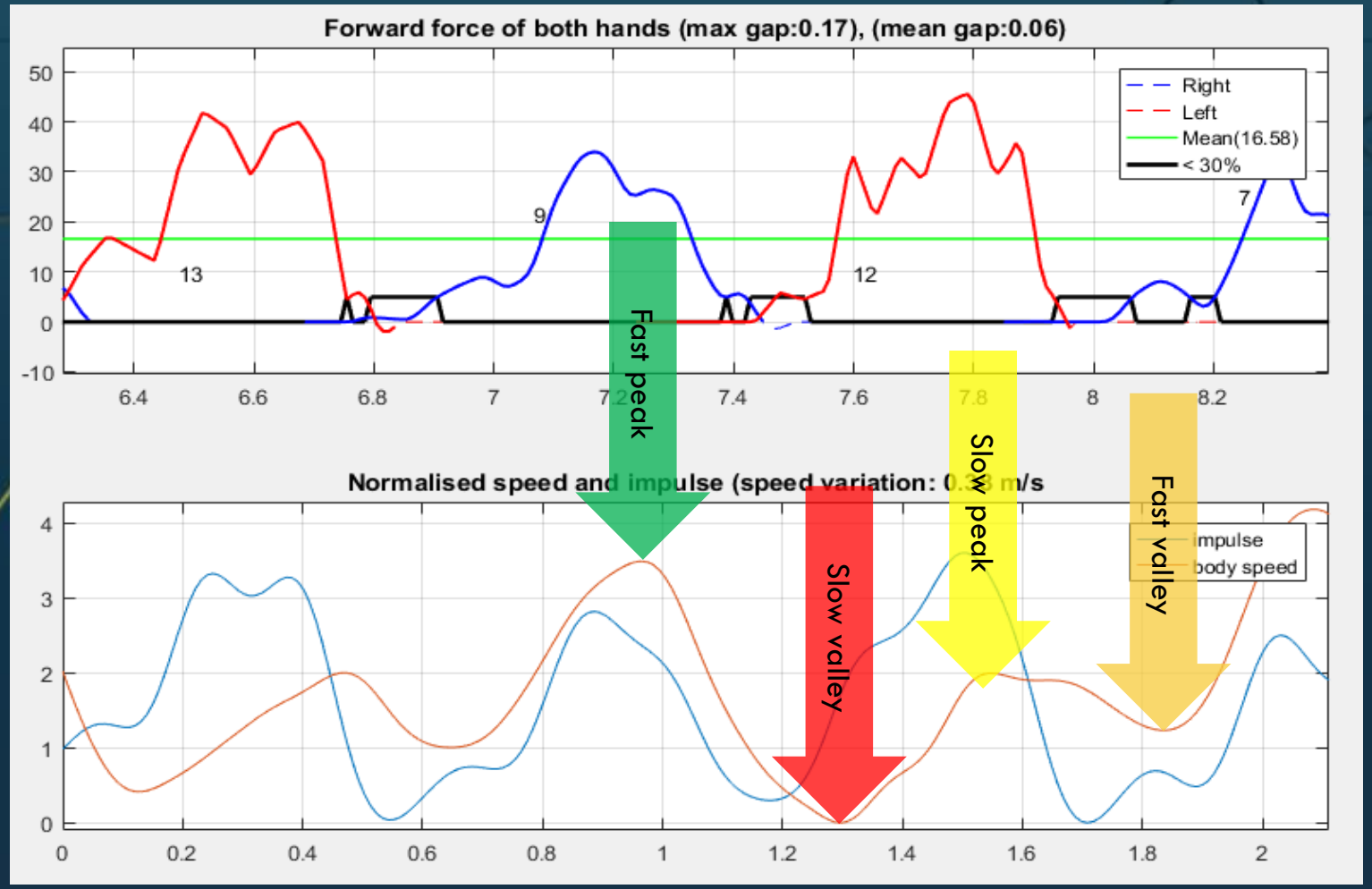
- Speed in the end of the stroke drops as the hand waits … for what ?
- For the right hand it takes time to get started in the front:
  -> slow hand deep in the water creates drag

Lat pull-ups on the pool side indicate limitations in the activation of the upper back in the late phases of the stroke

- Unstable movement
- Shoulders turning forward
- Max reach limited

Example2:
small intracycle velocity variation
small dependency to force

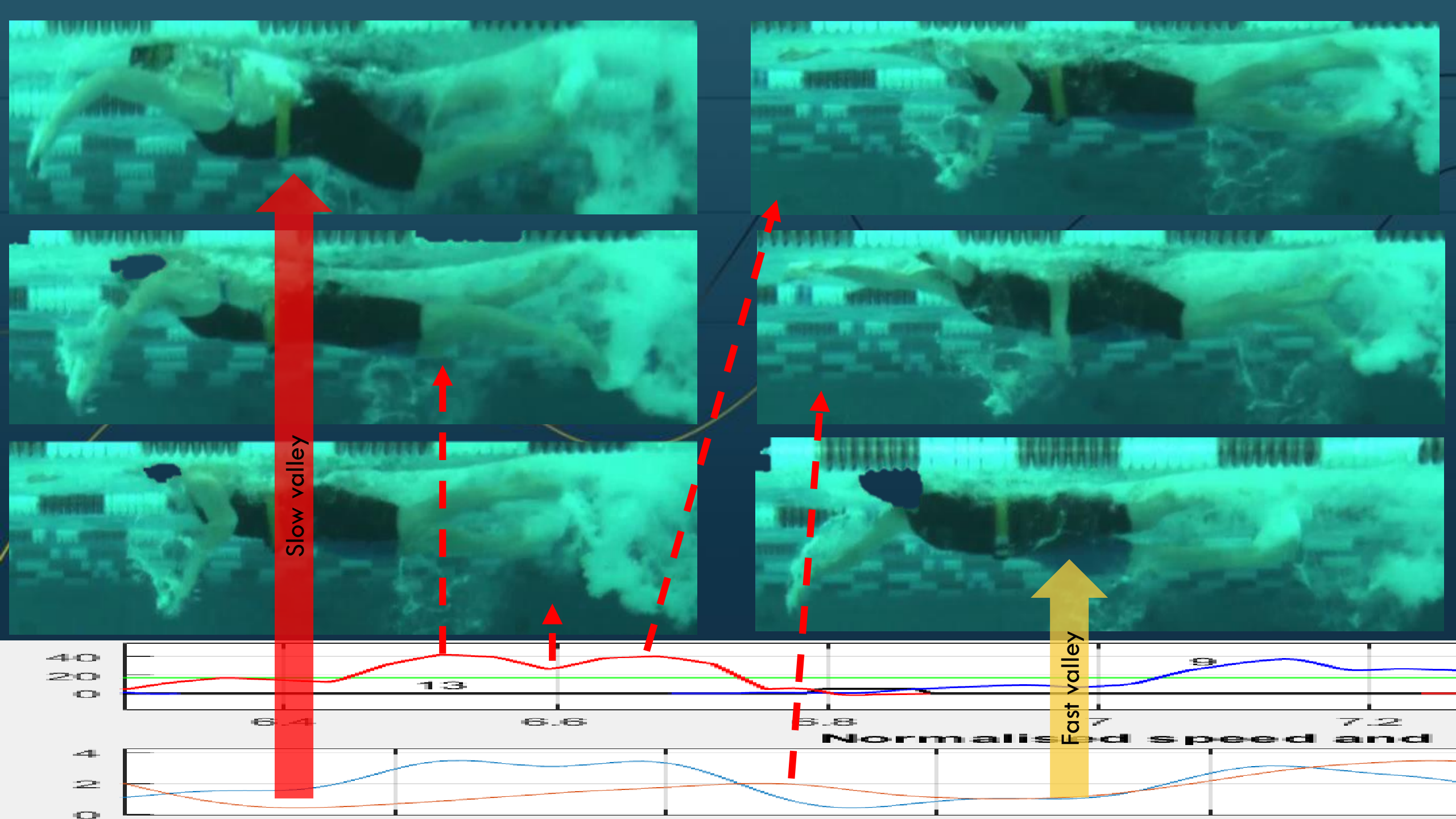
Body speed vs impulse

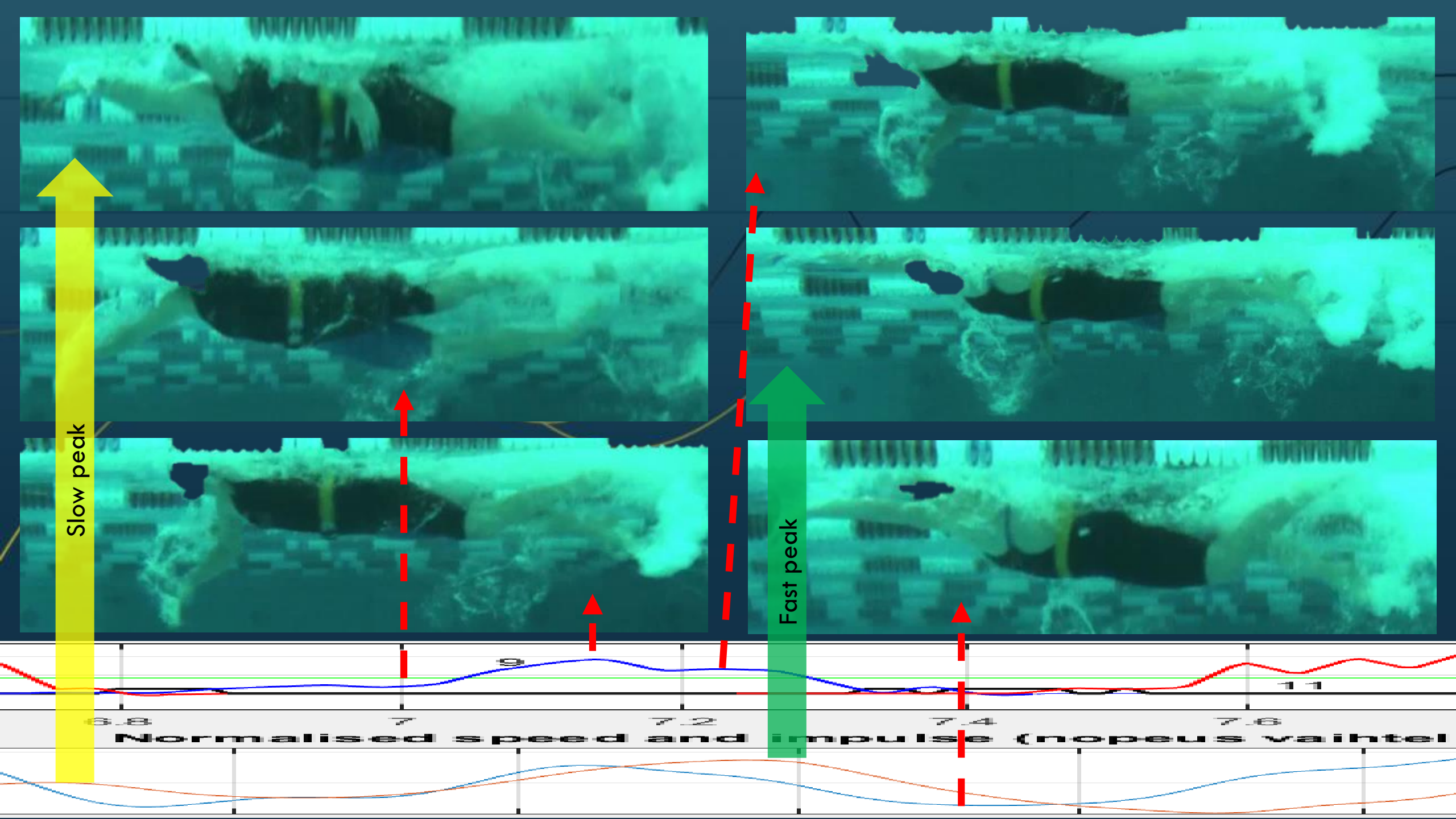


Small dependency due to variating drag from body&legs

Small variation due to high frequency (54 SPM)

- Right hand creates highest velocity by more steadily increasing force
- Left hand force is not visible in velocity due to drag from body & left leg
- Slowest point is when the right hand has been in water for 0.3sec


Slow valley
Fast valley
40
20
0
13
9
6.4
6.6
6.8
7
7.2
Normalised speed and
4
2
0


Slow peak
Fast peak
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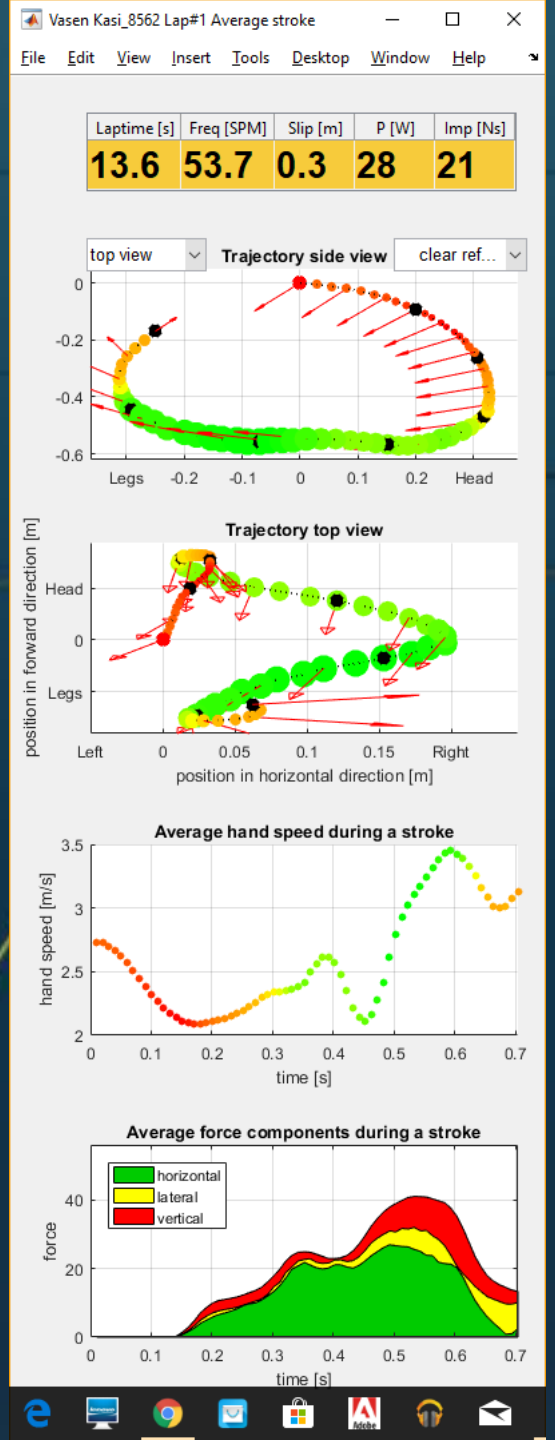

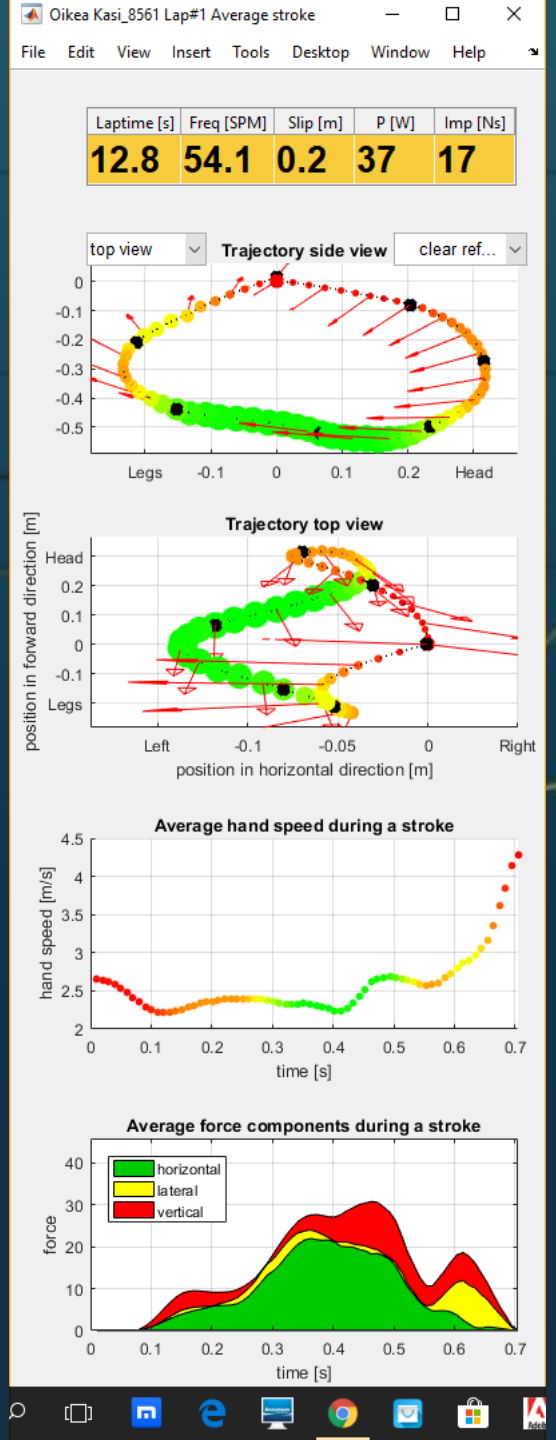

Additional information on SmartPaddle single hand data

Intactness of force profile

- Right hand
  - During the power phase hand moves in&out and up
  - -> hand followed by rotation
  - In the end of power phase, shoulder has escaped and only possible thing is to lift the hand from water
- Left hand
  - During the power phase hand remains in the same depth
    -> force created by hand and shoulder
  - Fast&unsteady acceleration and force ramp for the left hand

Gaps in the force

- In the end of the stroke each palm turns inside early in upsweep
- Especially for left it takes time to start creating force