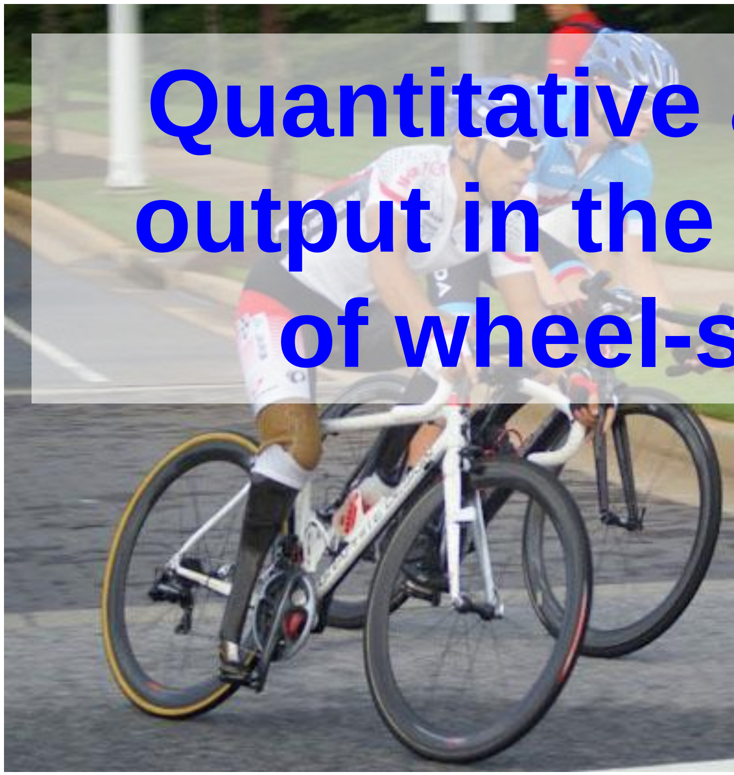
東京大学 THE UNIVERSITY OF TOKYO

UTSSI UTokyo Sports Science Initiative 東京大学スポーツ先端科学研究拠点

BLUEWYCH LTD.

Quantitative analysis of power output in the field performance of wheel-sports athletes.



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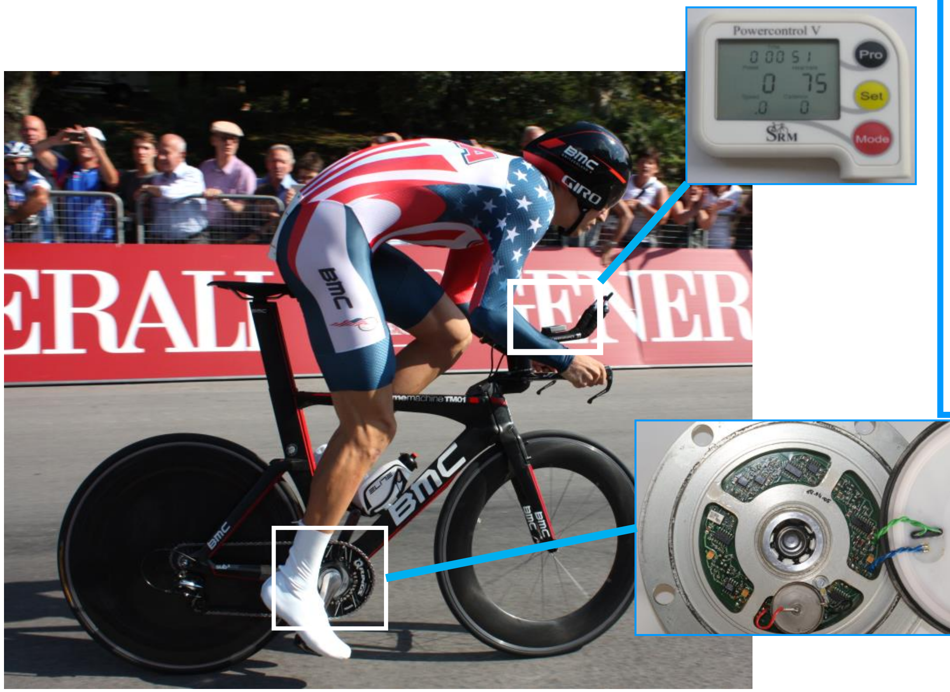
Outline:

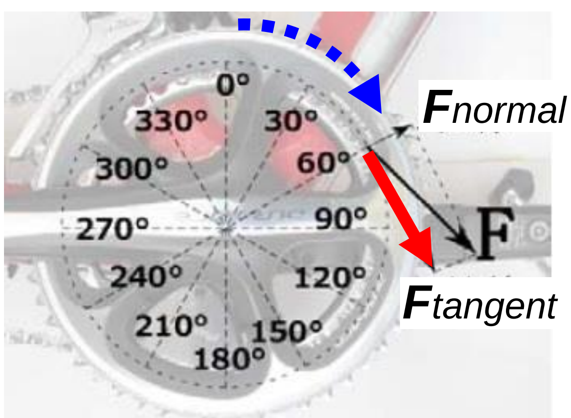
1. Power analysis in Cycling
2. Application of Power analysis to Para-cycling
3. Application of Power analysis to Wheelchair racing

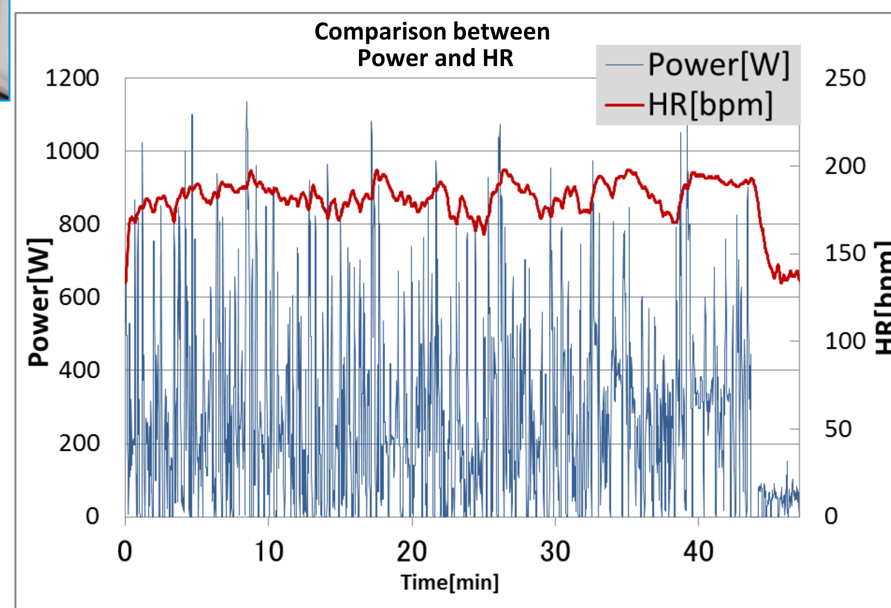
Powermeter: a tool for quantifying the power

- This tool can quantify the power/force output of a rider by measuring the torque coming from the legs with strain gauges in the crank and cadence of pedaling.

- Measured data is recorded in the data logger on handle.



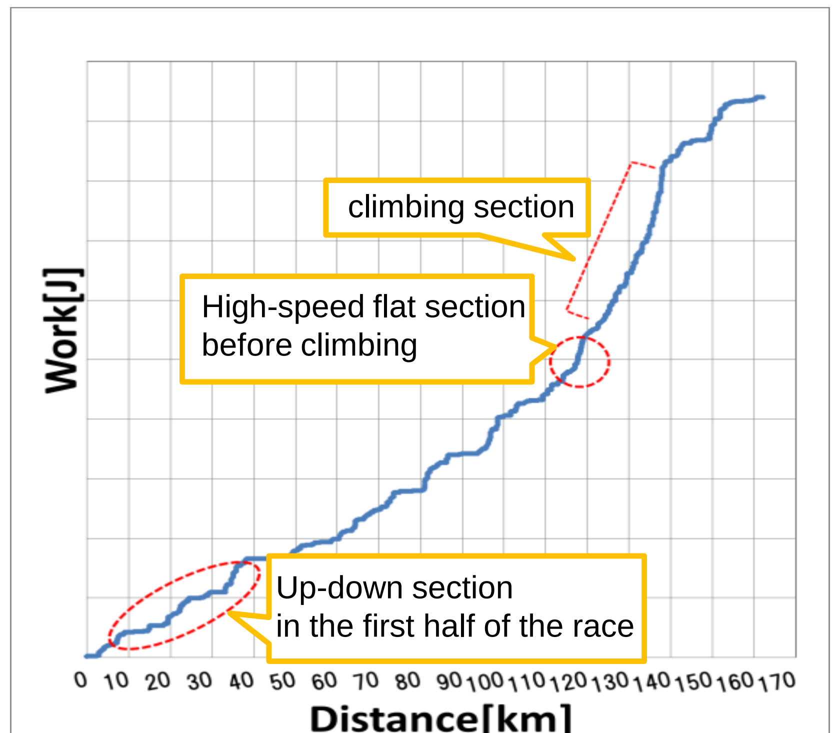




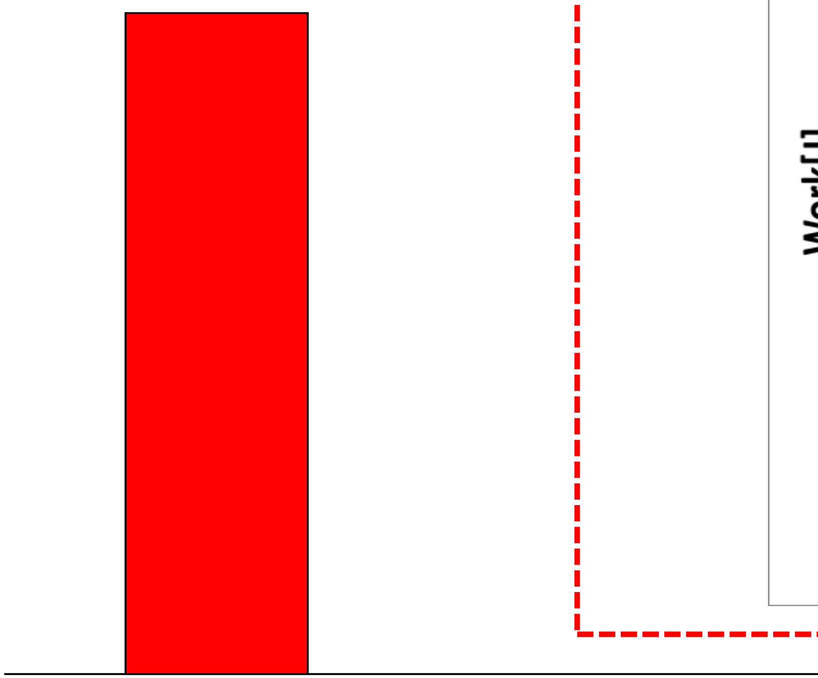
Utilizing the powermeter as “wearable sensor” on bicycle

①Quantification of “Goal”

Measuring temporal changing work
⇒ Grasping the performance process in the race
Grasping the related matters with the capacity of a rider in the race



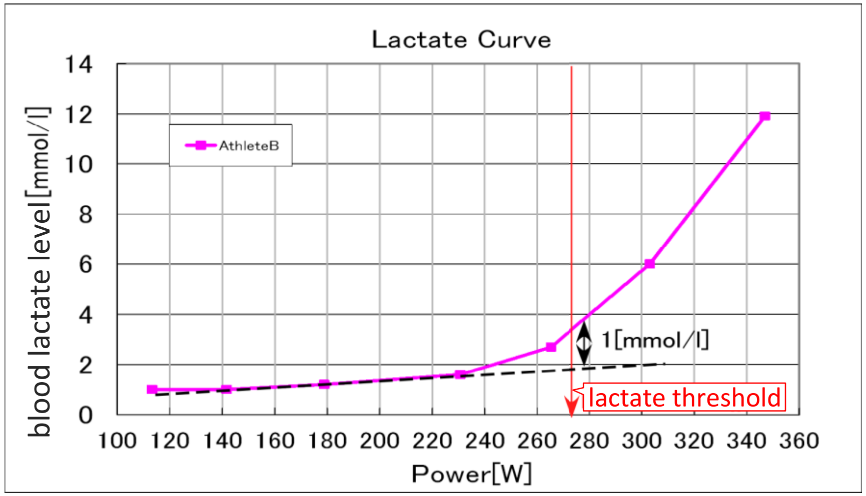
①How much capacity is required in the target race?



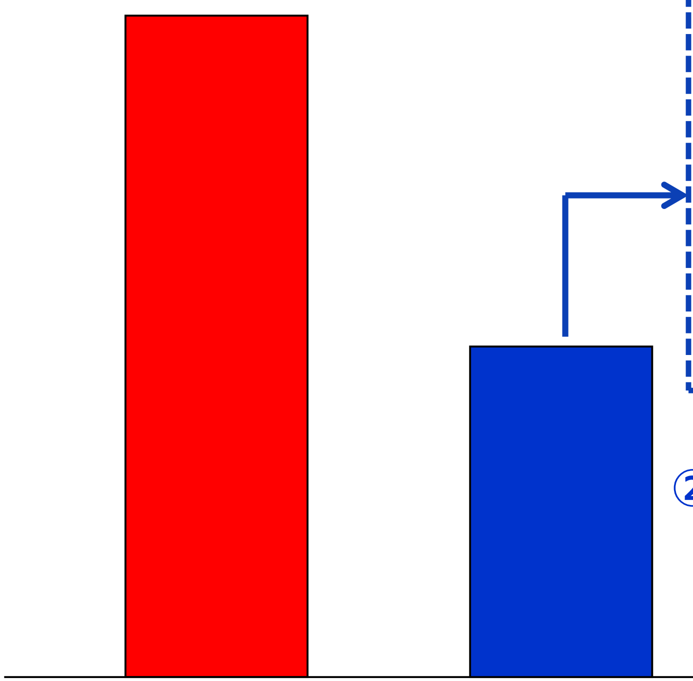
Utilizing the powermeter as “wearable sensor” on the bicycle

②Quantification of “Rider’s capacity”

Identifying the lactate threshold, the predictor of potential race performance, with the incremental load test

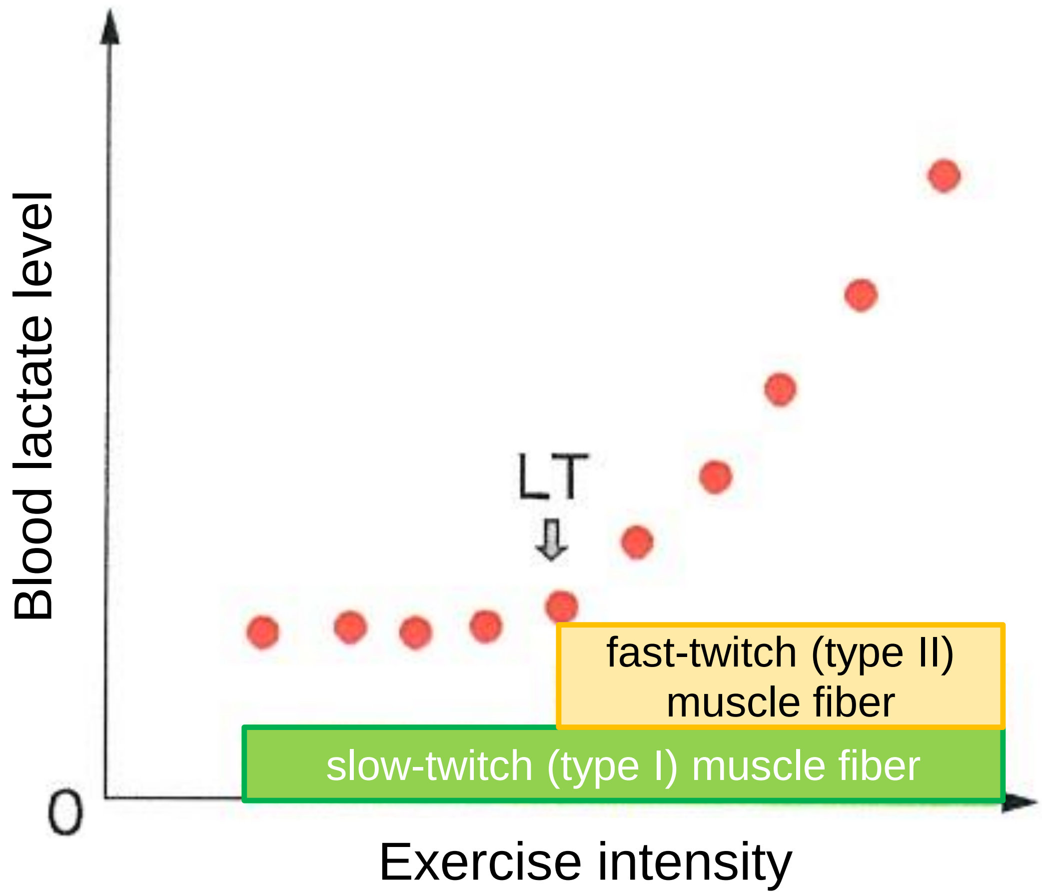


①Required capacity



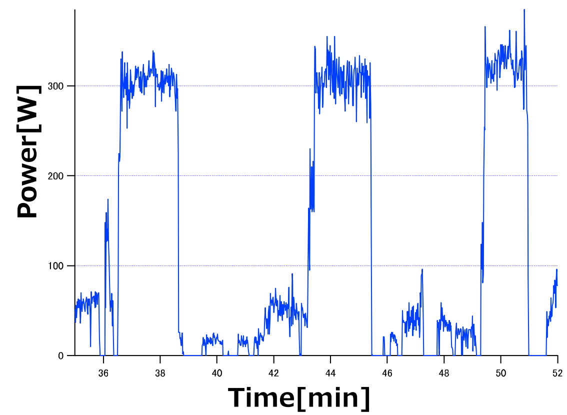
②How much is the current capacity of a rider? (fundamental ability, technique, tactics …)

LT (Lactate Threshold)
: Exercise intensity at a sharp increasing of glucose utilization



From LT, fast-twitch muscle fiber is mobilized.

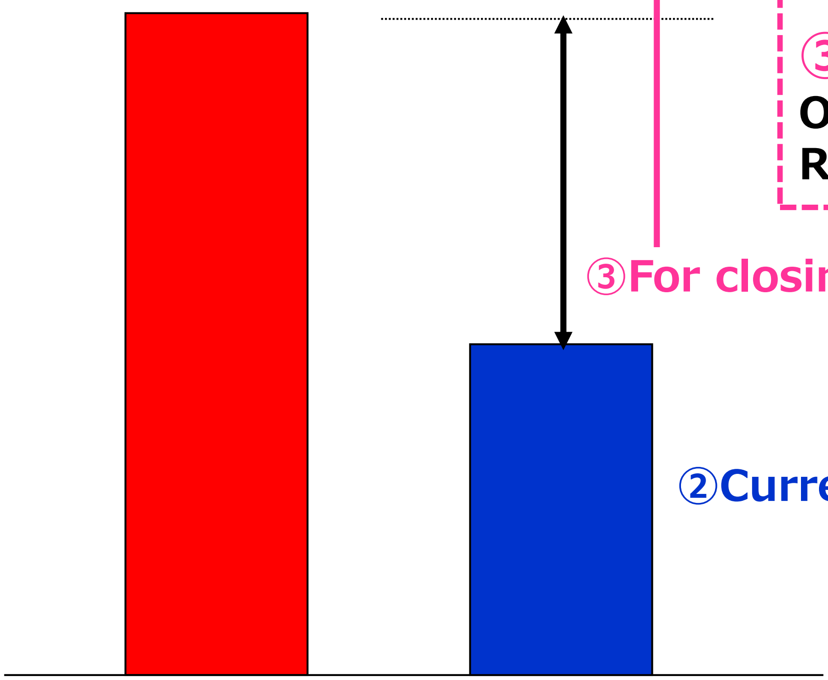
Utilizing the powermeter as “wearable sensor” on the bicycle



③Quantification of “Training”

Optimizing the training intensity and time
Recording the training history

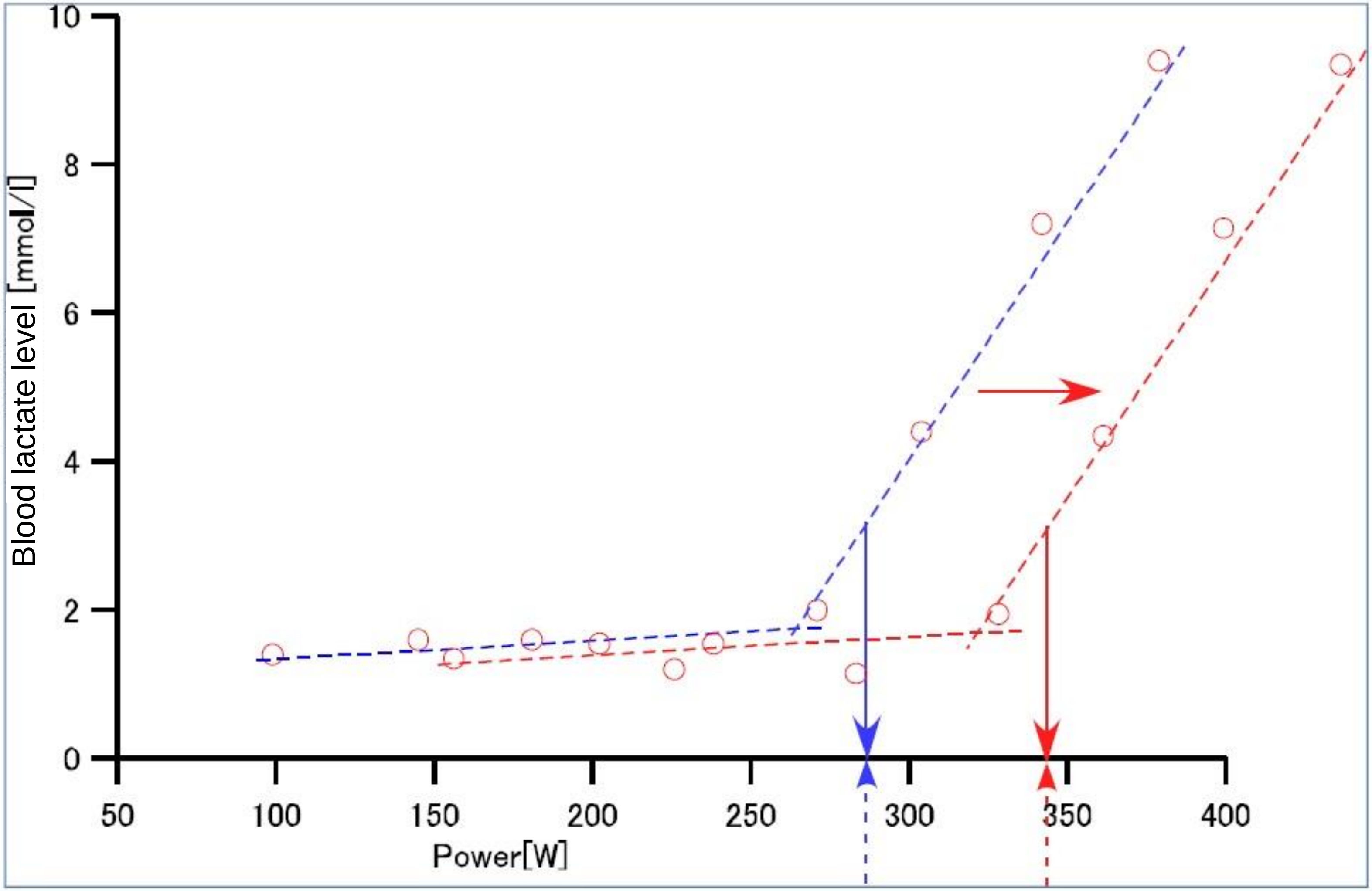
①Required capacity



③For closing this gap, how does a rider train?

②Current capacity of a rider

Right-shift of Lactate curve ＝Improvement of the endurance capacity

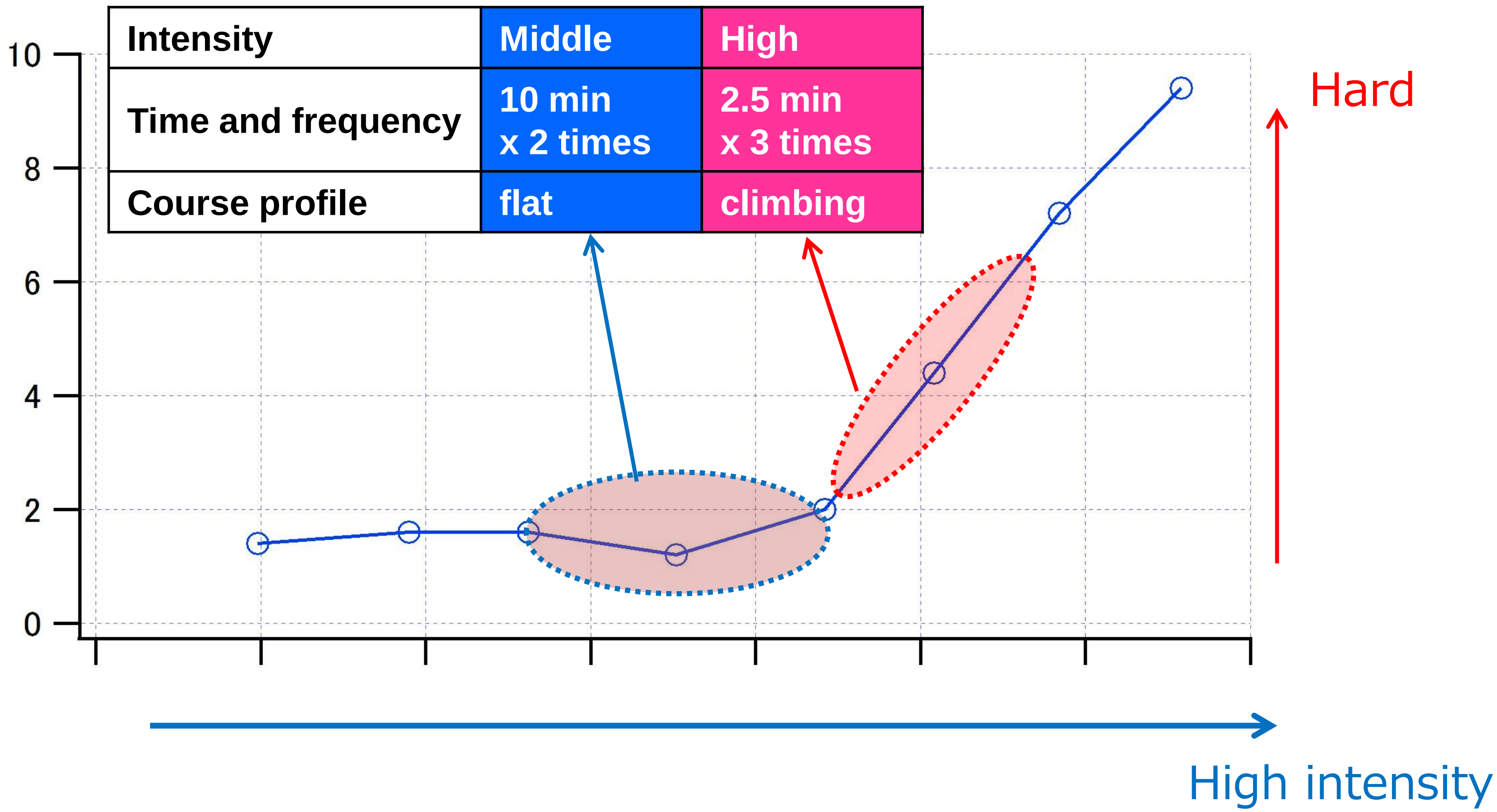


Carrying the Power-training combined with utilizing power meter and measuring LT

An example of training composition at a day

(The intensity of each training menu is shown on the lactate curve schematically)

Intensity	Middle	High
Time and frequency	10 min x 2 times	2.5 min x 3 times
Course profile	flat	climbing

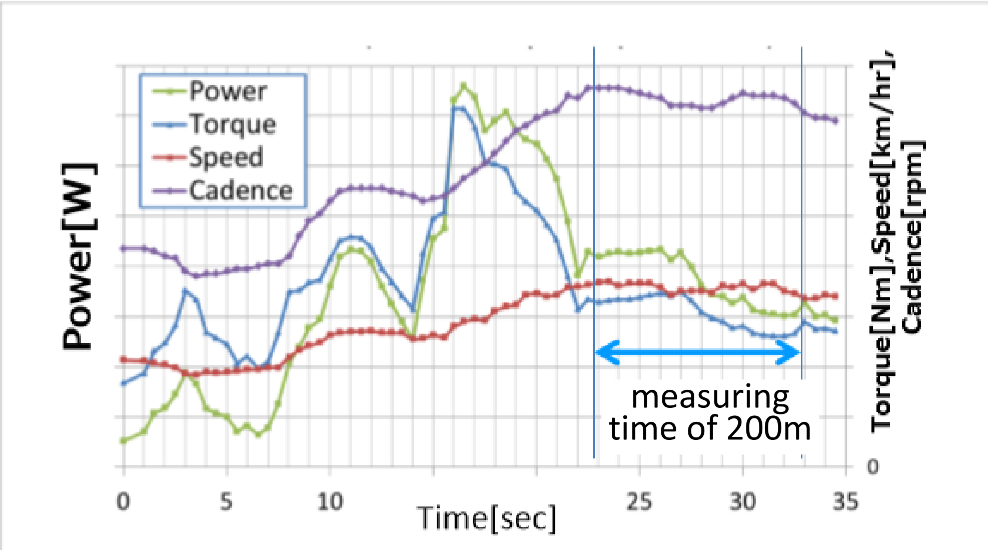


Indicator for evaluating sprint performance

<u>200m Flying Time Trial</u> : The performance period is the shortest.
The acceleration force is the major element.

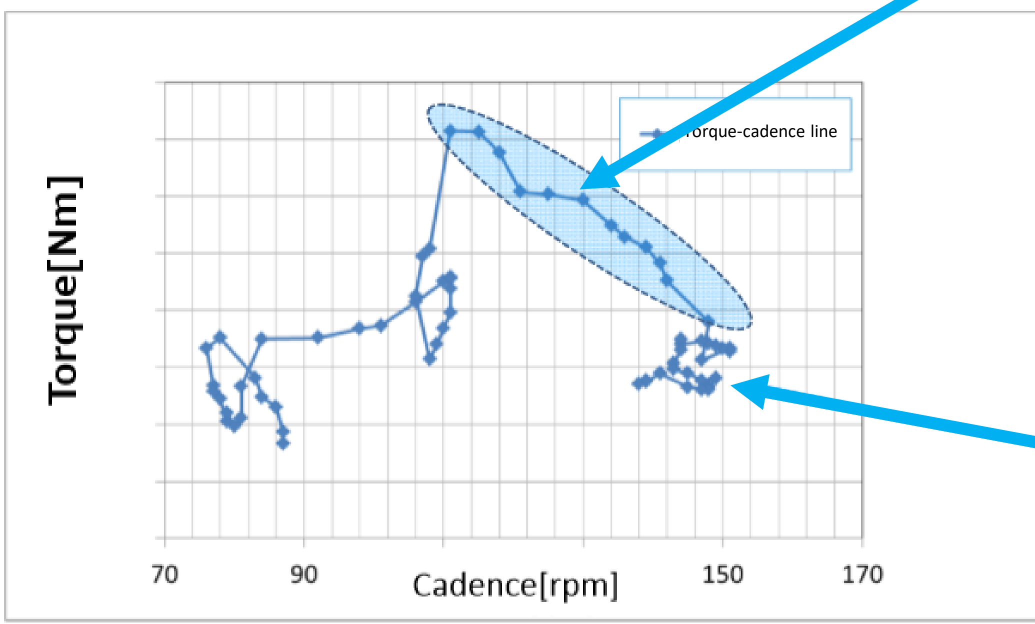
Evaluating with power, torque, and cadence during flying.

1. Power analysis in Cycling



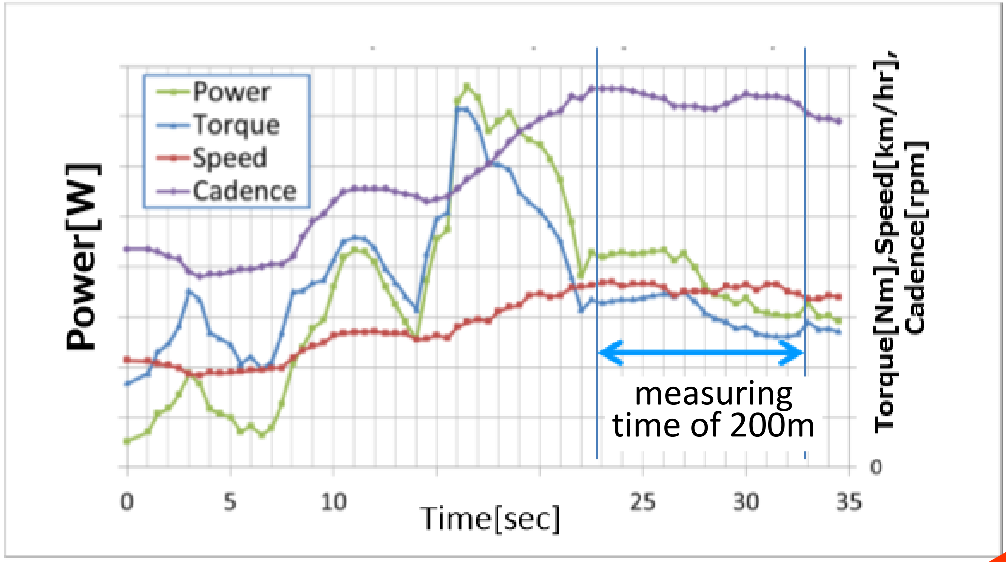
Torque and cadence of pedaling are in a linear relationship during acceleration.

Anthony J. et al., J Appl. Physiol. 51(5):1175,1981
A. Scott Gardner et al., Eur. J. Appl. Physiol. 101:287,2007

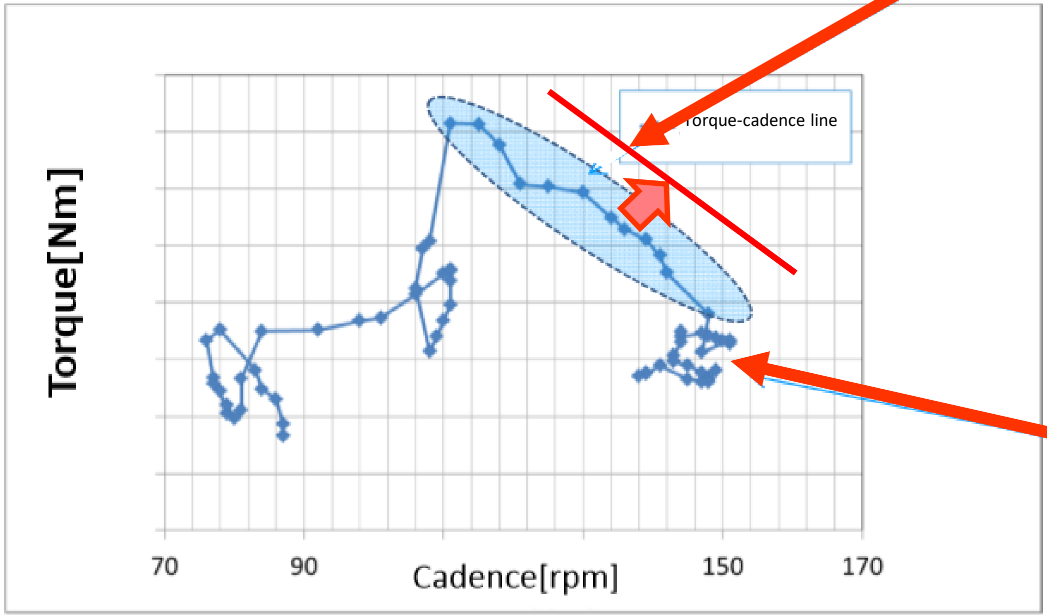


During 200m (approx. 10 sec), and the rider endures excerting the sufficient torque in the peak cadence (142~152 rpm) to keep the speed.

1. Power analysis in Cycling



Track bike: fixed gear

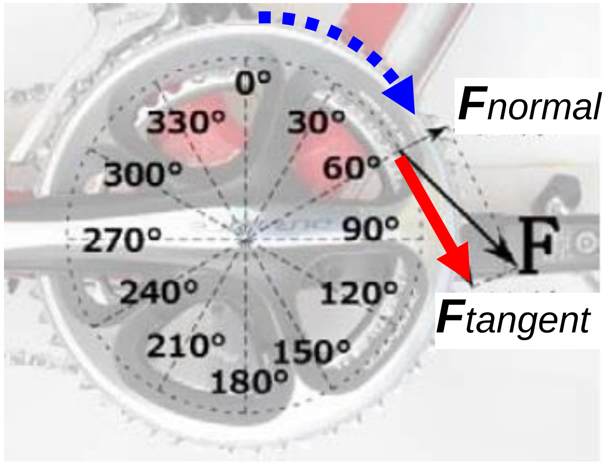


Shifting torque-cadence line to the upper-right

Increasing the peak cadence

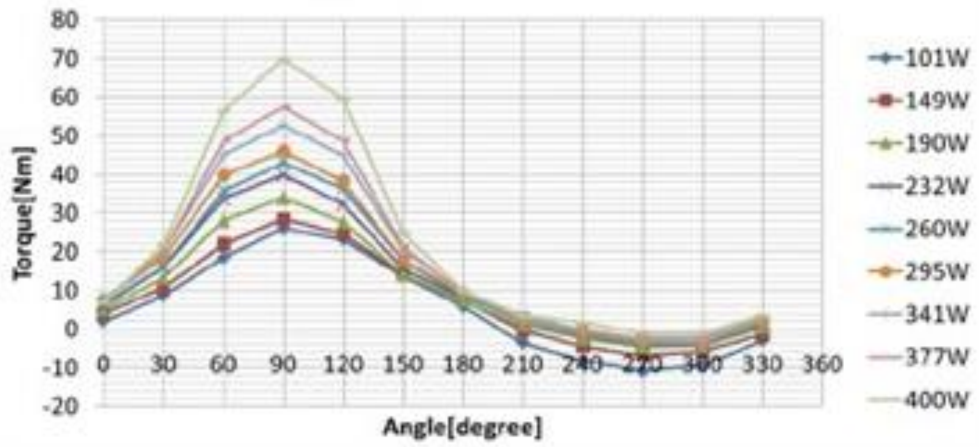
Extracting the moment of sprint performance with power analysis

Torque distribution

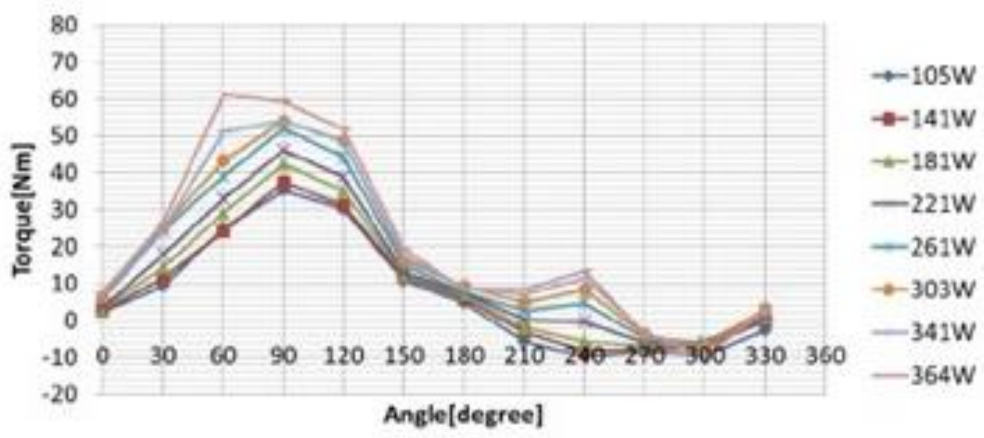


with POWERMETER (PIONEER Co., Japan)

Professional rider

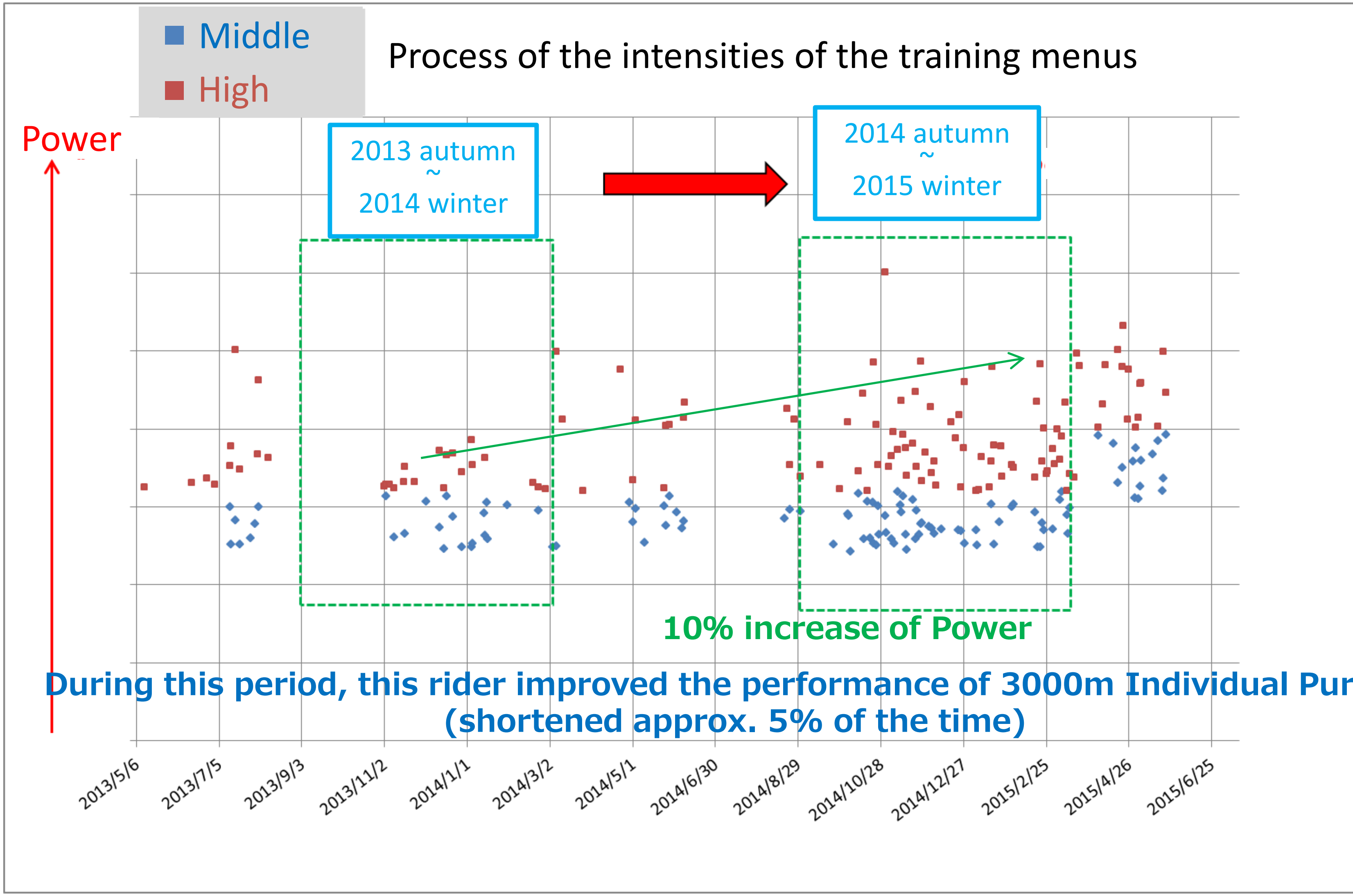


Amateur rider



Extracting the technique of pedaling with power analysis

Power training is effective for the paracycling riders to improve the performance



Application of power analysis to developing the prostheses for double below-knee amputated rider

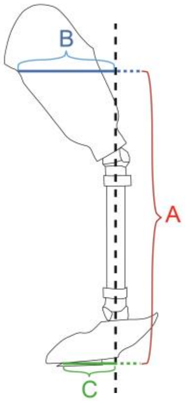
<u>Requirements</u>

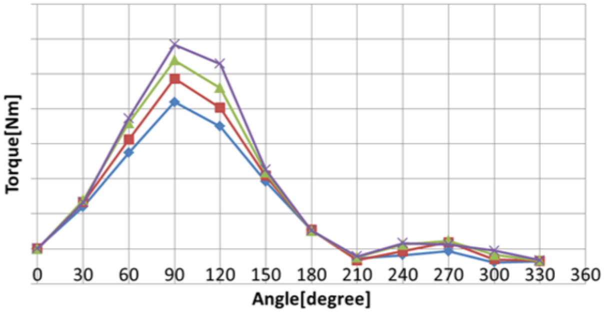
- All equipments must meet UCI equipment regulations.
- No energy storage or assistance mechanism is integrated into a prosthesis.

Both legs below knees are amputated.
⇒ Is the limitation loose or severe?

What is the optimized form/alignment of the prosthesis?

Adjustment of the alignment of the prostheses for maximizing the rider's potential through the power and motion analysis





Compare the parameters regarding the power (torque distribution, LR ratio, efficiency etc)

Fabricating endoskeletal prostheses for measurements

↓

Power and motion analysis
Rider's subjective evaluation

↓

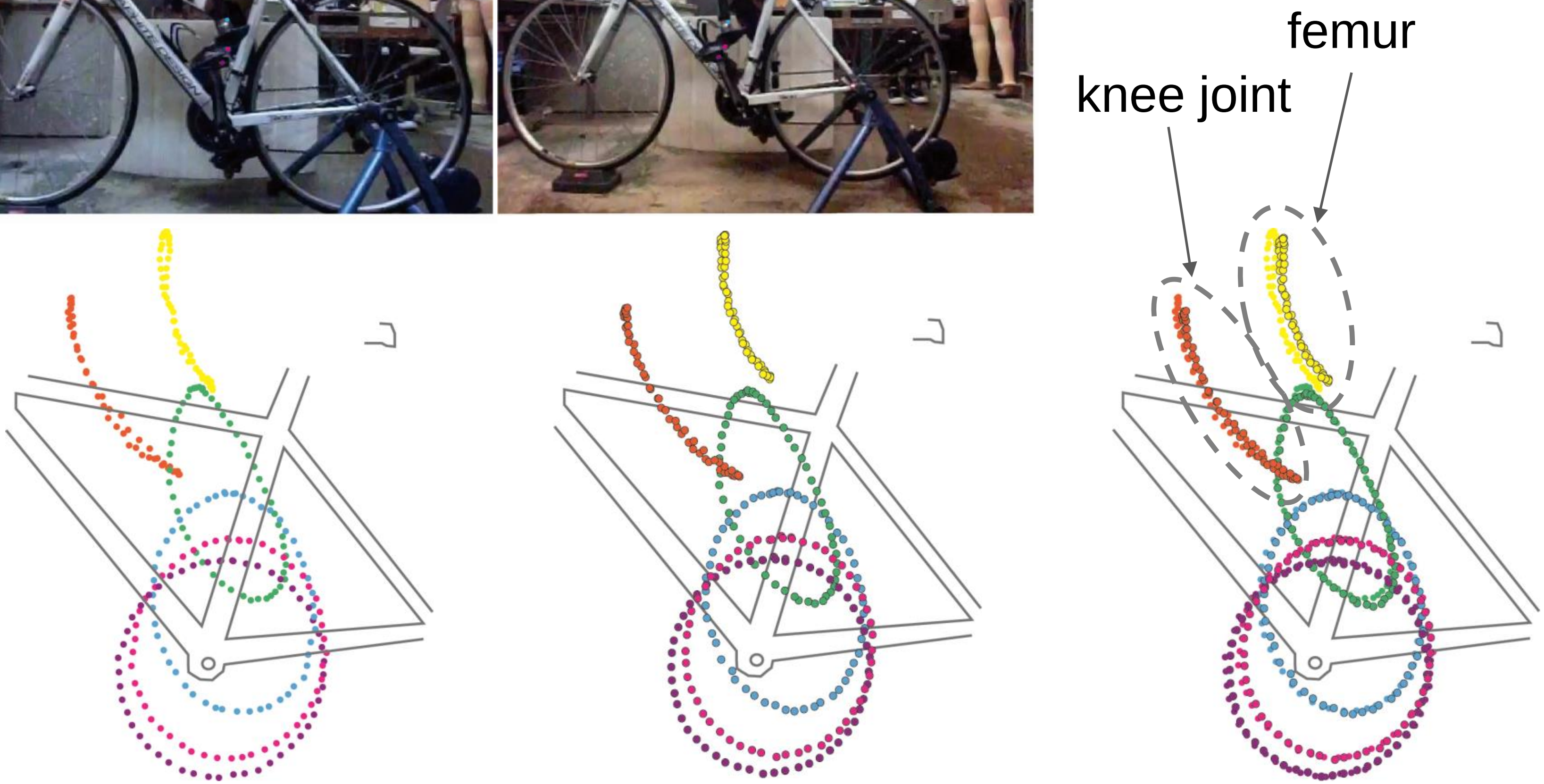
Confirmation of the optimized design

↓

Fabricating exoskeletal prostheses for competitions

Slight modification of the length can affect the pedaling movement

Before change of the length After change of the length

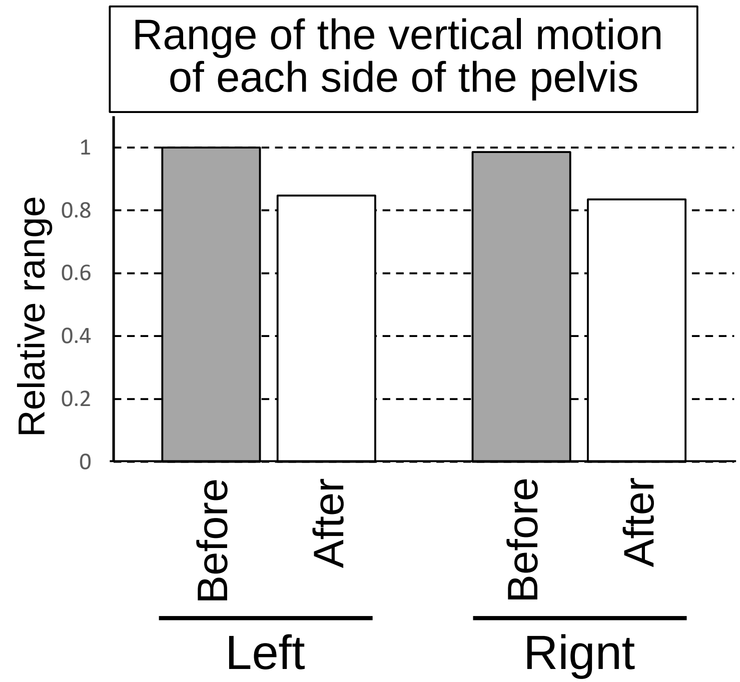


Before change After change Merged

The modification of the length of the prosthesis can affected to the movement of the hip joint

Before change

After change



The vertical motion of the pelvis was reduced

↓

Improved the stability

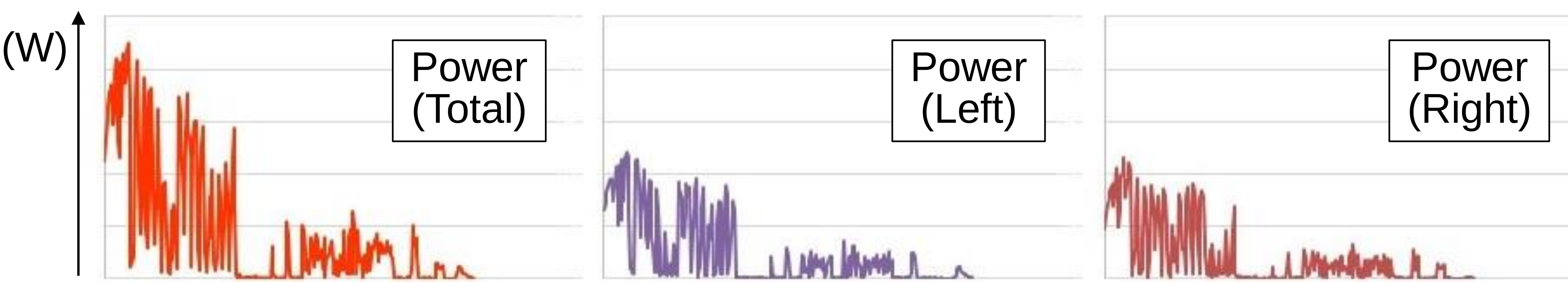
The alignment of cycling prosthesis may have a severe limitation

Even if the length and angle are modified slightly, pedaling performance can be affected.

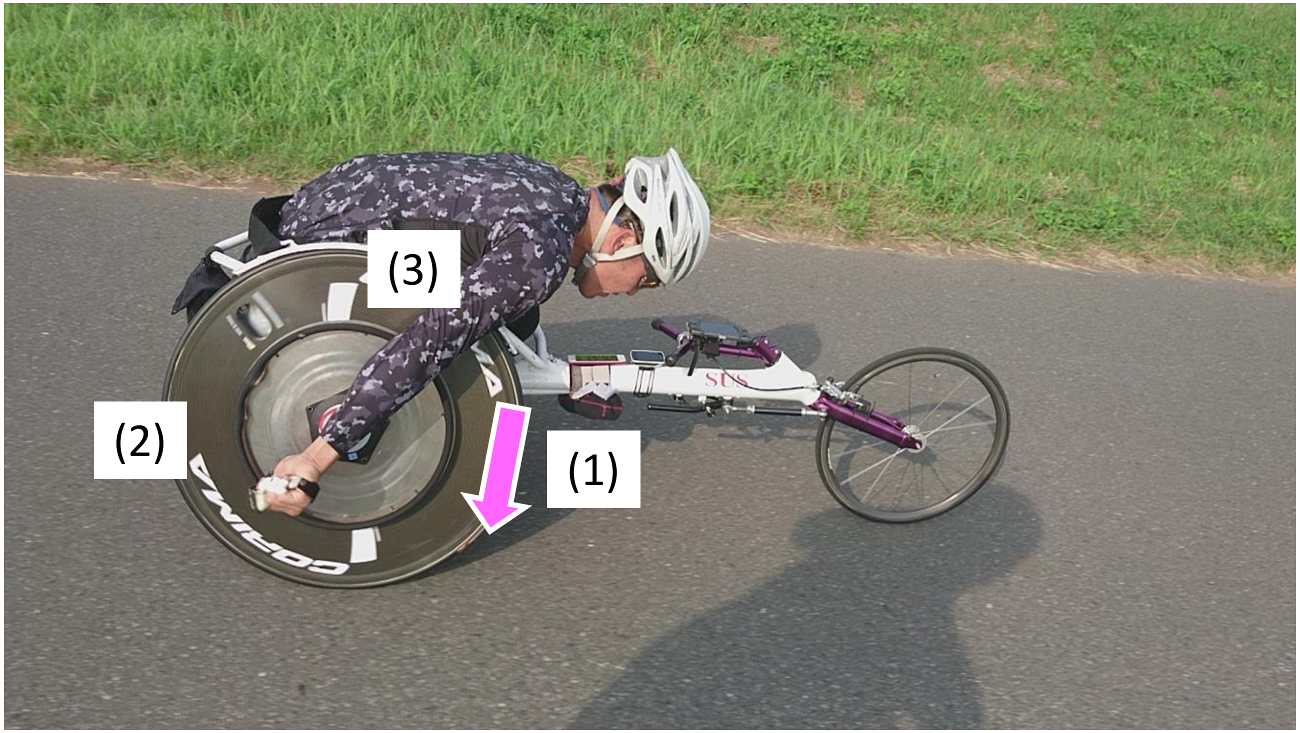
It is assumed that the limitation is defined by the rider’s physical characteristics and riding position.

Developing a wheel to measure the power output during running in the field

Attachment of SRM power meter to wheelchair racer wheel



Power＝Torque loading on a handrim × cadence of a handrim
(W) (N・m) (rad/s)

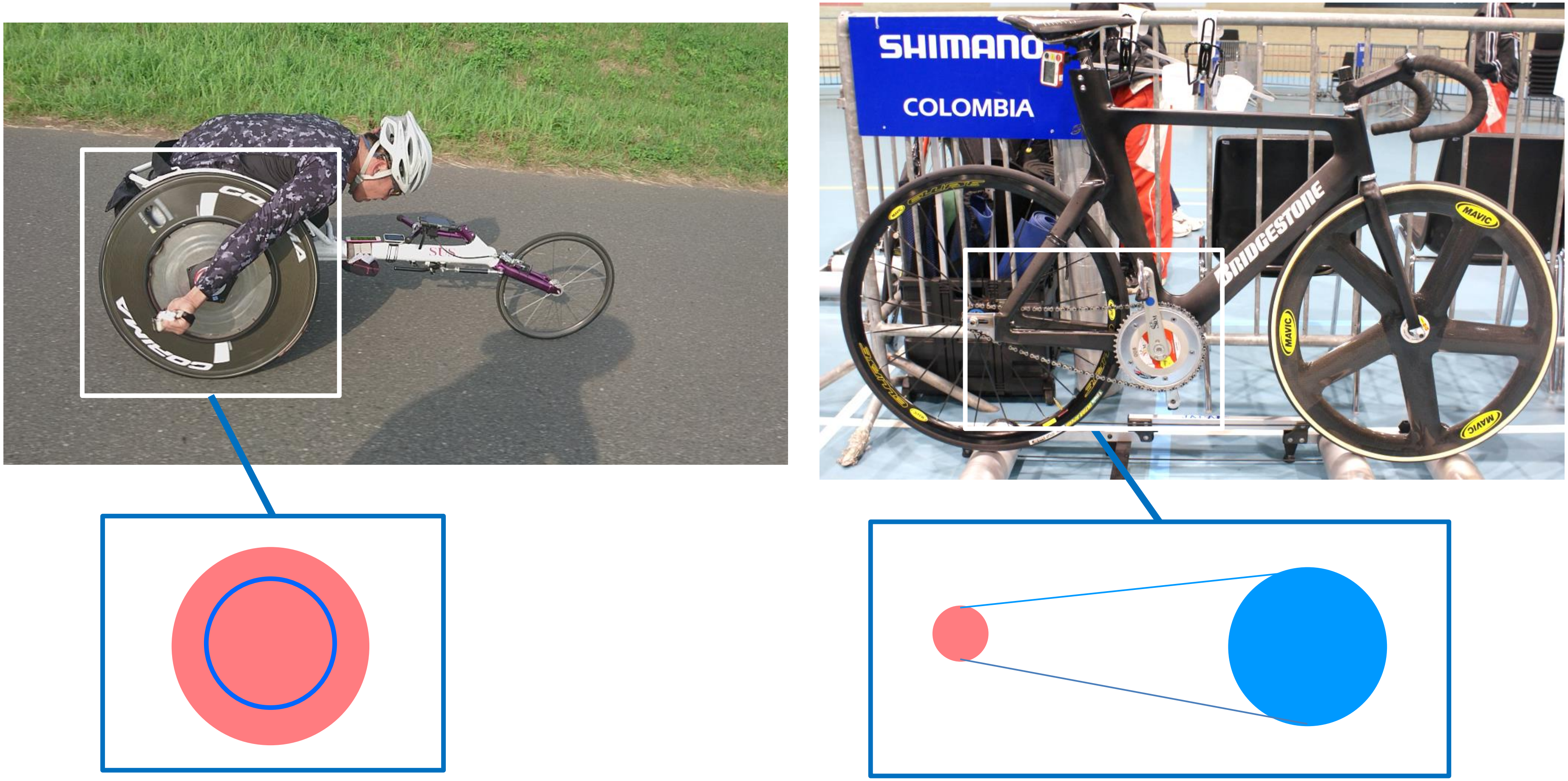


(1) Force along the tagent line of a handrim

(2) Cadence of a handrim

(3) Pitch of an arm

3. Application of Power analysis to Wheelchair racing

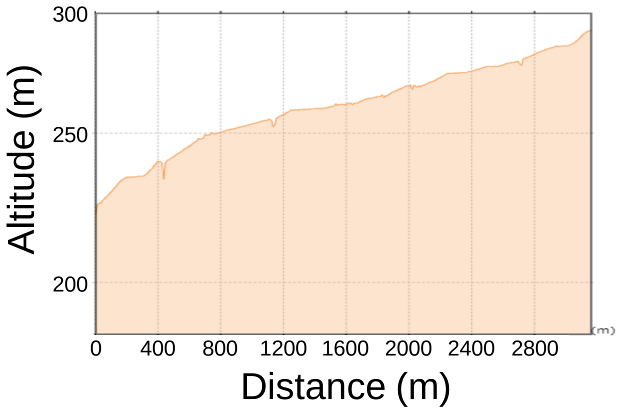


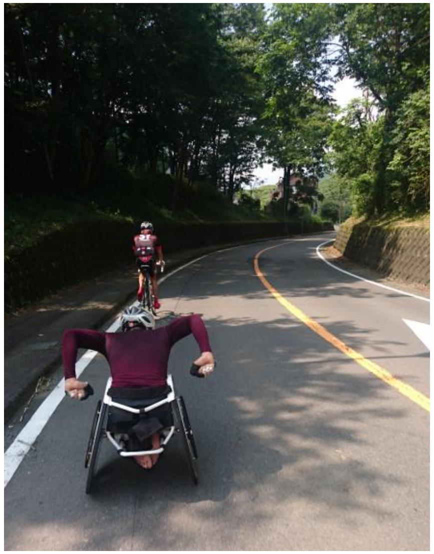
In either vehicle, the loading point from the limbs (handrim or pedal) is connected to rear wheel to generate forward movement.

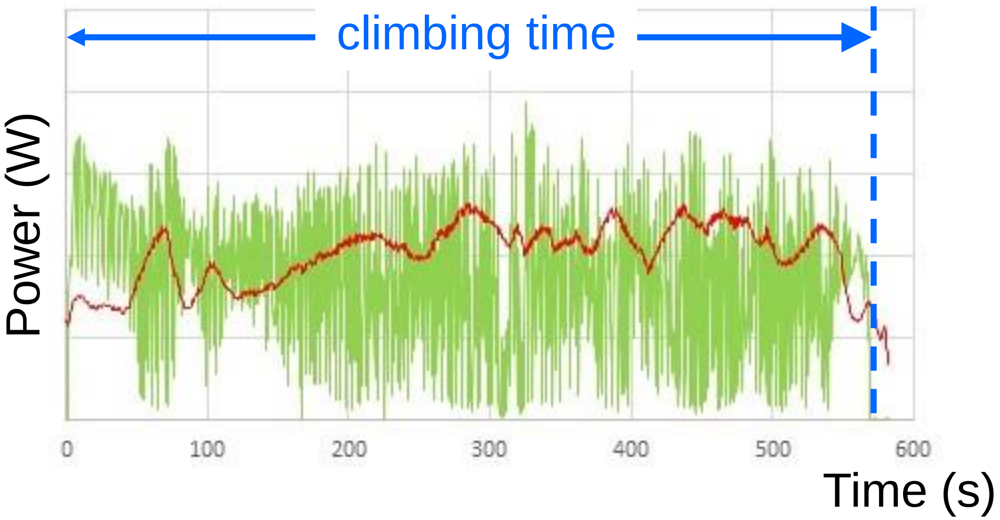
Otherwhile, a leg is fixed to a pedal, but an arm is not fixed to a handrim.

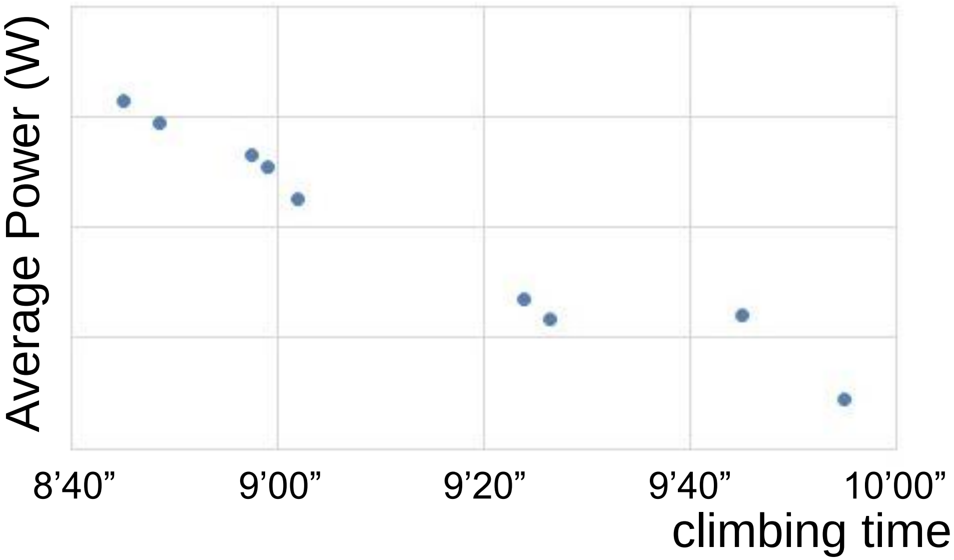
An example of the training data

< Course profile >
Tokyo, rural region
Distance: 3160m
Average slope: 1.9%





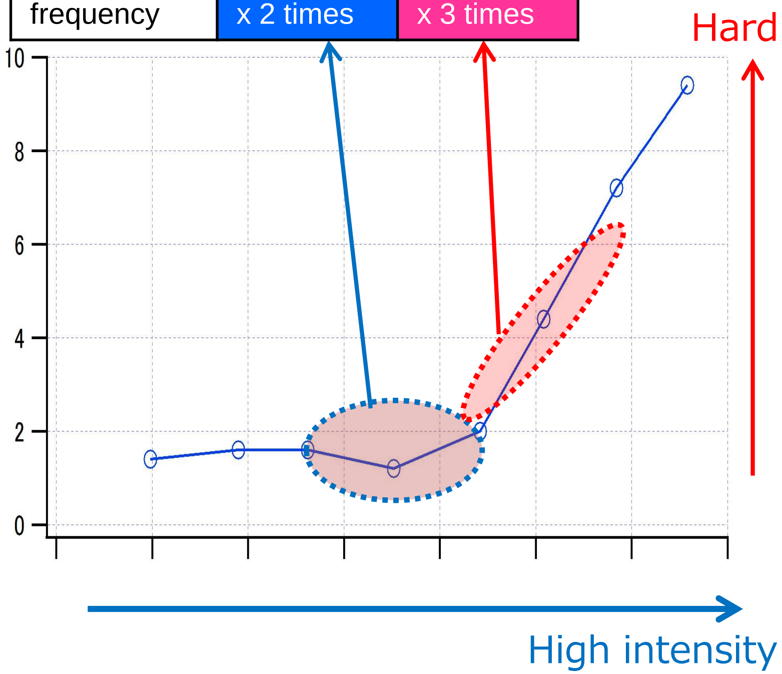




Negative correlation between the average power and the climbing time.

The progress of wheelchair runner's performance by carrying out power training (case rep.)

Intensity	Middle	High
Time and frequency	10 min x 2 times	2.5 min x 3 times



Average power of 10 min run

apprx. 5% increase of Av. Power during 2months training

Concluding Remarks:

- Power analysis can extract various elements of cycle sport performance, and can evaluate the rider’s abilities and characteristics quantitatively.

- Power analysis can provide the effective training for improving the rider’s endurance capacity with the physiological parameters like lactate threshold, and can monitor the progress of the athlete.

- Power training method can be adapted to the cycling athlete with the impairment, furthermore, be applied to developing the optimizing equipment which is specific for the impairment.

- Many elements of wheelchair running performance are common with that of cycling performance, otherwise, there are also the different elements between these sports. Defining and extracting these elements are effective to provide more optimized training, and the power analysis may be a strong approach to investigate.

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