Daily handcycle settings during sub-maximal handcycling

Effects of gear, imposed resistance and crank mode on the mechanical efficiency and physiological parameters during sub-maximal handcycling in healthy men

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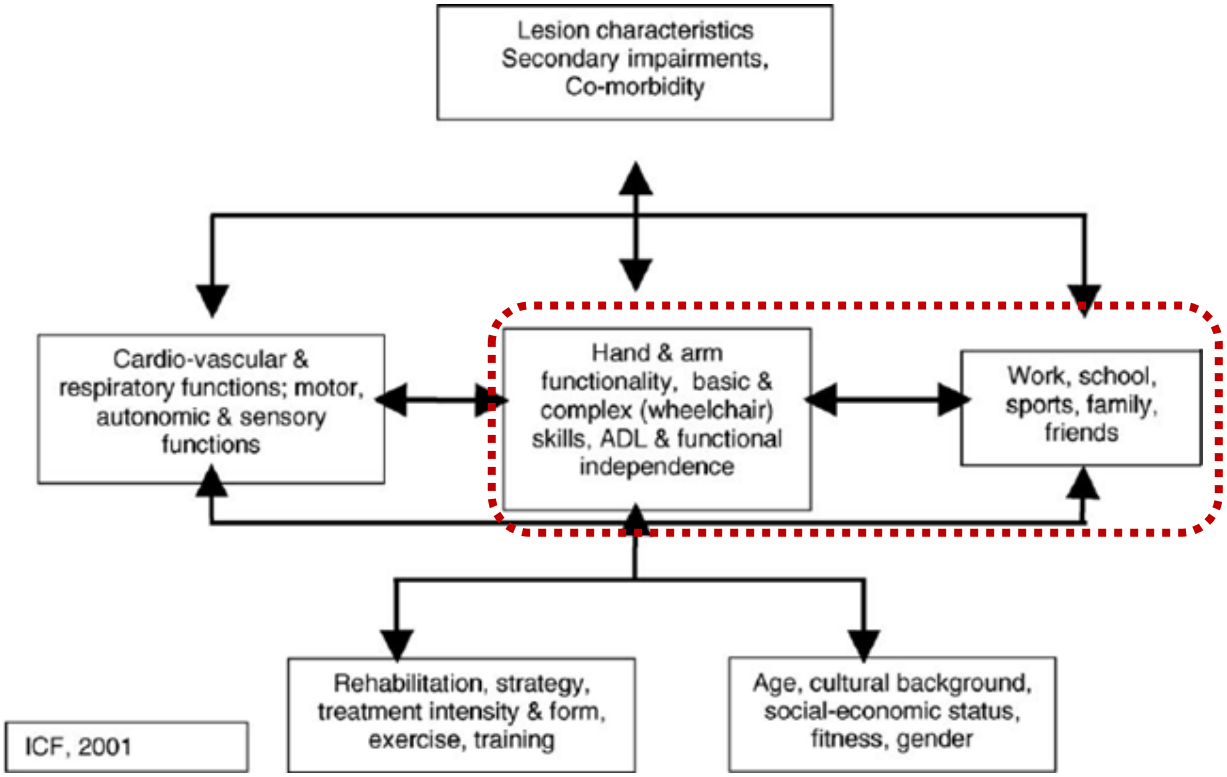
WWU MÜNSTER

Something different…

- Handcycling
  - Alternative to the manual wheelchair
  - For outside use only
  - Higher speed can be reached
  - Longer distances can be covered
- Two types
  - Fixed-frame
  - Add-on
    - Use for daily transportation

van der Woude LH V, Dallmeijer AJ, Janssen TWJ, Veeger DH. Alternative modes of manual wheelchiar ambulation. Am J Phys Med Rehabil. 2001; 765–777. doi:10.1097/00002060-200110000-00012

Theoretical background



WHO 2001

Optimize user-interface

- **Total work capacity: 30-40% lower than in the legs**

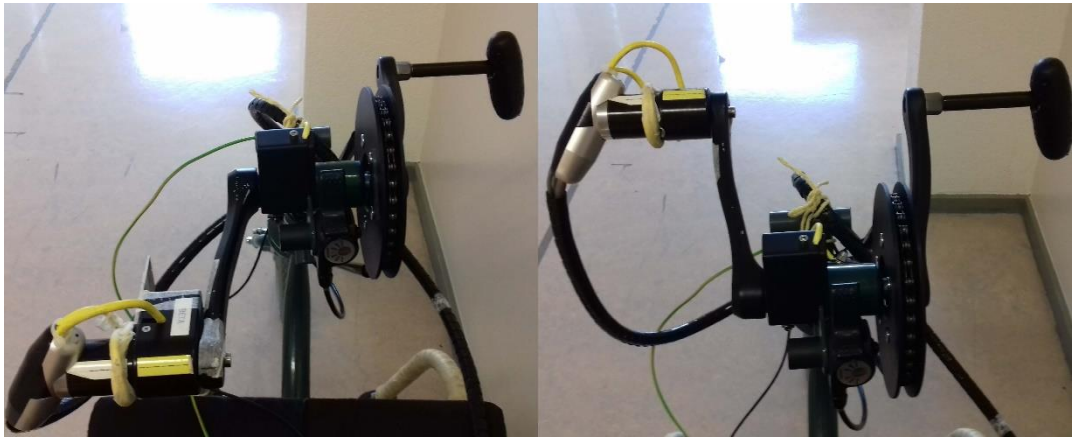
- Peak VO_2 = 60-70% legs
- Peak PO = 30-70% legs
- Gross ME = 2-15%

- The HR and VO_2 during sub-maximal work is higher than in the legs
- Blood pressure is higher than in the legs

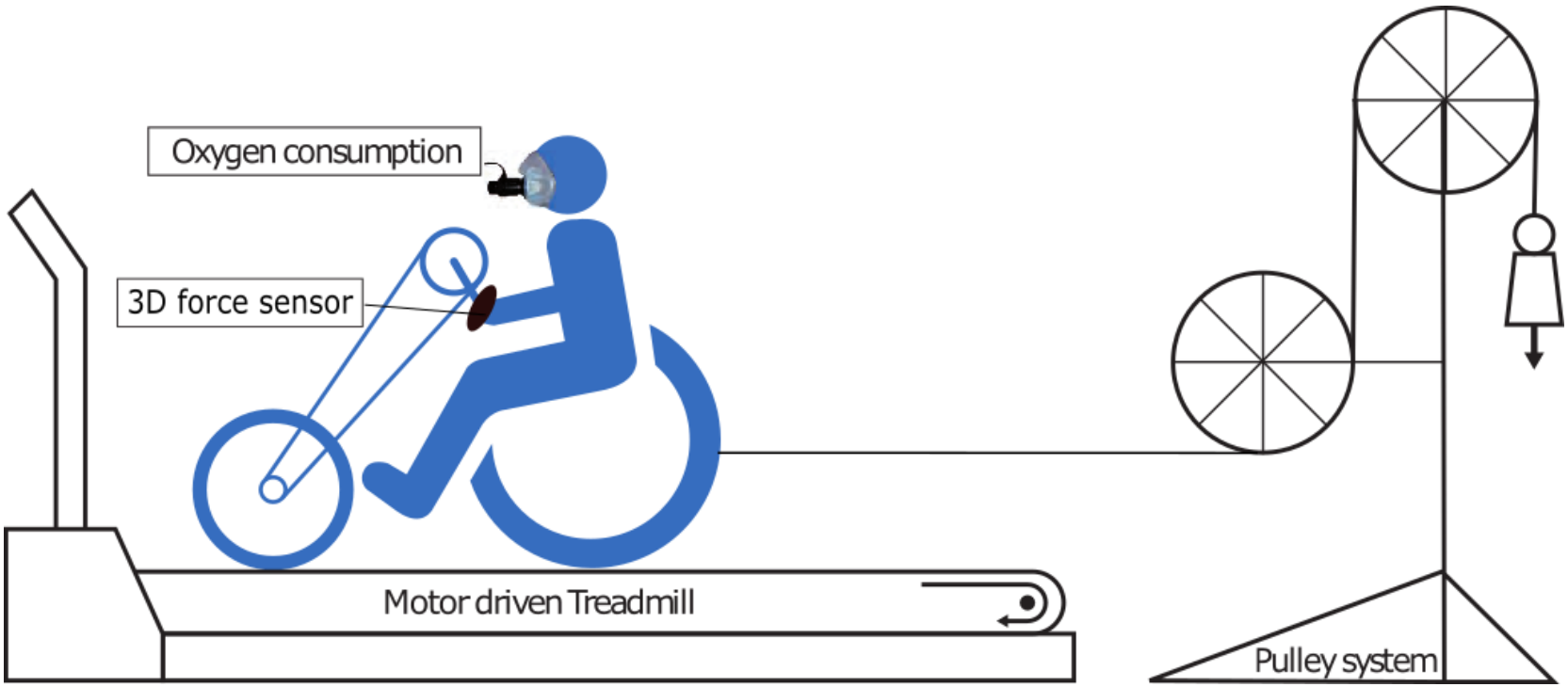
Eston RG, Brodie DA. Responses to arm and leg ergometry. Br J Sports Med. 1986 Mar;20(1):4-6
Freyschuss U. Comparison between arm and leg exercise in women and men. Scand J Clin Lab Invest. 1975 Dec;35(8):795-800

Explore handcycle settings

- Gear
  - Cadence
  - Hand velocity
- Imposed resistance
  - Slope
  - Overall velocity
  - Pulley system
- Crank mode
  - Synchronous
  - Asynchronous

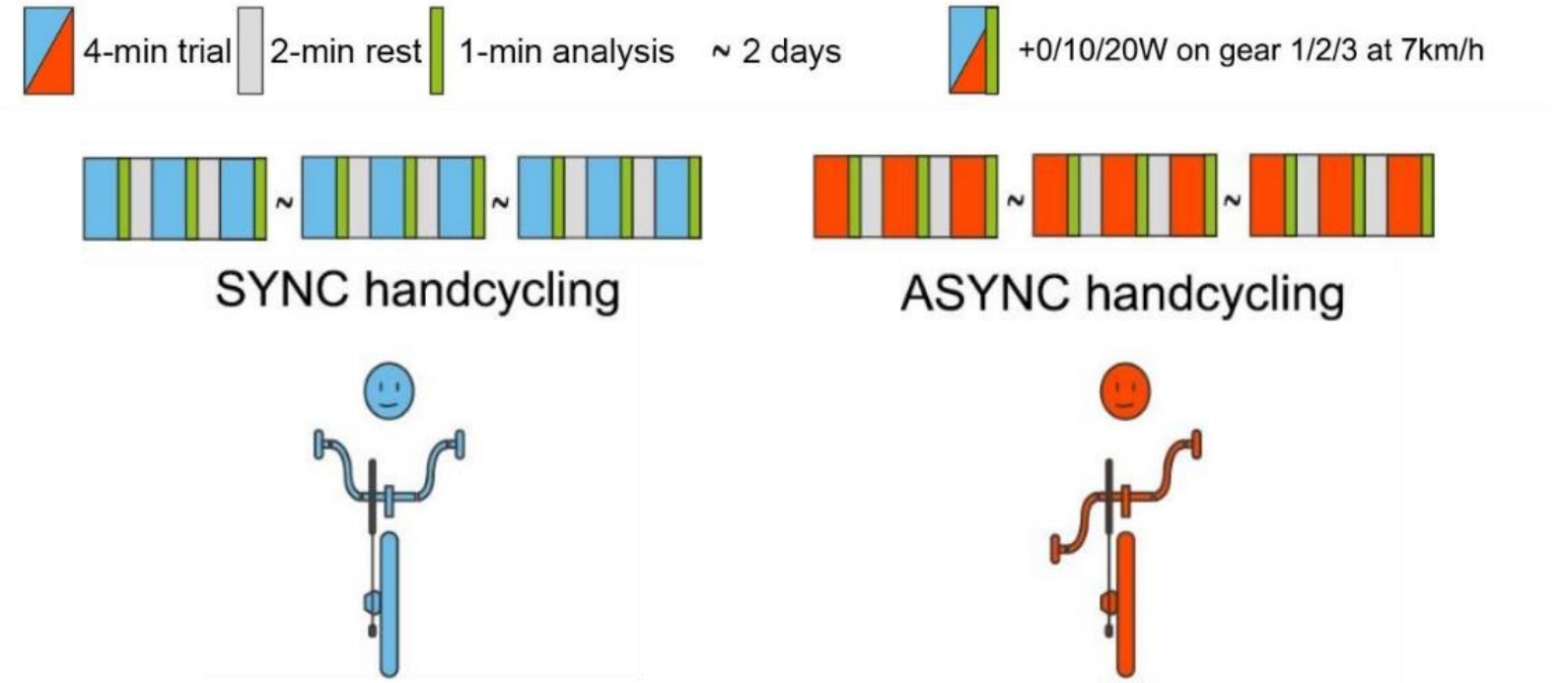


Set-up



Kraaijenbrink et al. Different cadences and resistances in sub-maximal synchronous handcycling in able-bodied men: effects on efficiency and force application *PLOS ONE* (Under Revision)

Protocol


4-min trial
2-min rest
1-min analysis
~ 2 days
+0/10/20W on gear 1/2/3 at 7km/h
SYNC handcycling
ASYNC handcycling

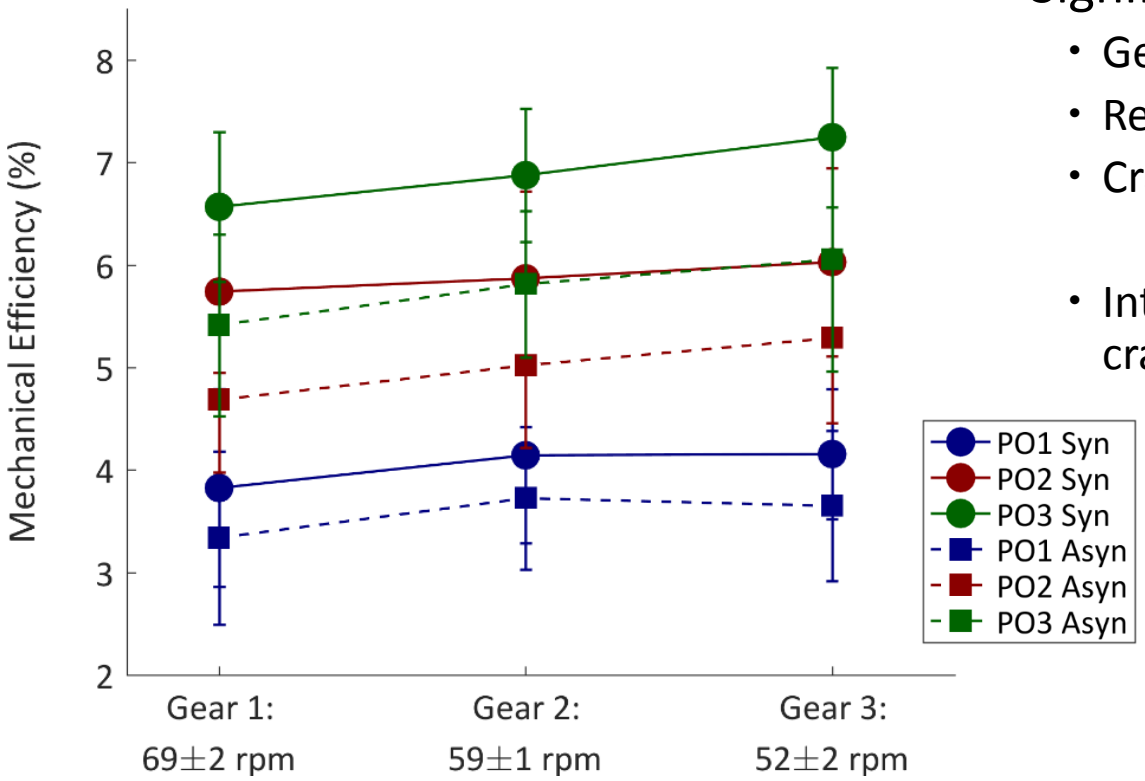
Data analysis

- Cosmed Quark CPET
  - Heart rate (HR, bpm)
  - Oxygen consumption (VO2, ml/min)
  - Carbon dioxide exertion (VCO2, ml/min)
  - Ventilation (VE, ml/min)

- Mechanical efficiency using PO of the synchronous situation
  - Tangential force and linear velocity at crank from instrumented handcycle

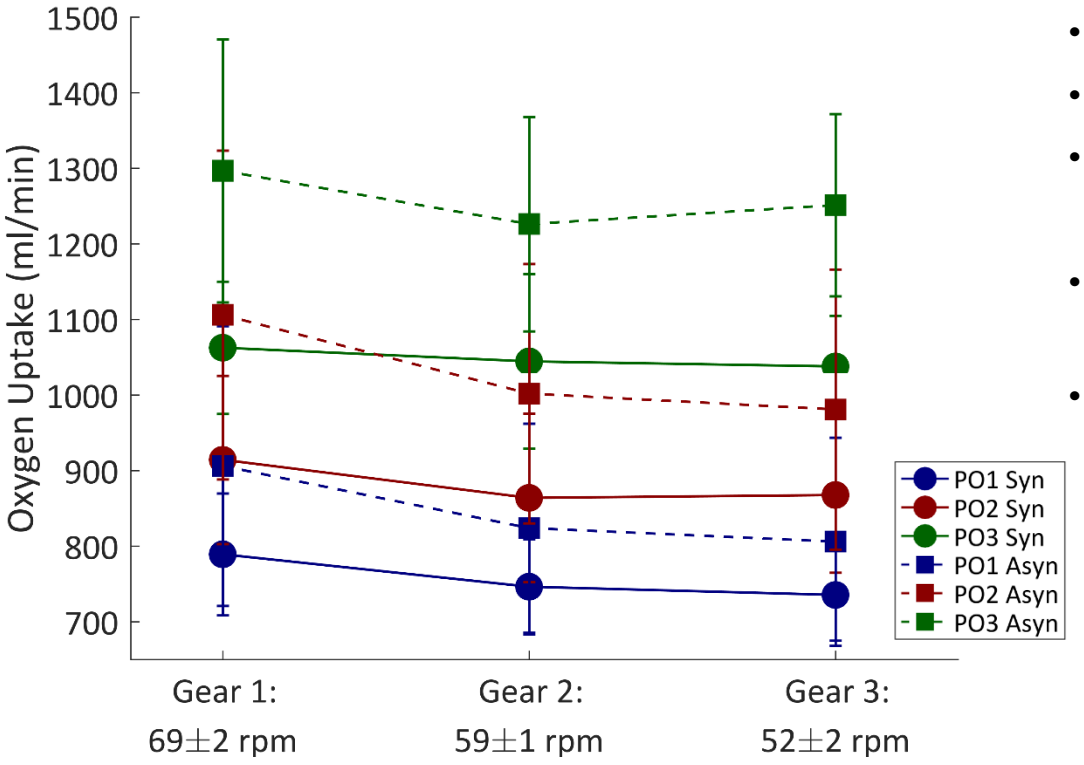
$$ME(\%) = \frac{PO_{syn}}{Energy\ Expenditure} \cdot 100\% = \frac{2 \cdot F_{tan,syn} \cdot v_{linear,syn}}{((4.94 \cdot VCO_2/VO_2 + 16.04) \cdot VO_2)/60} \cdot 100\%$$

Effect on mechanical efficiency



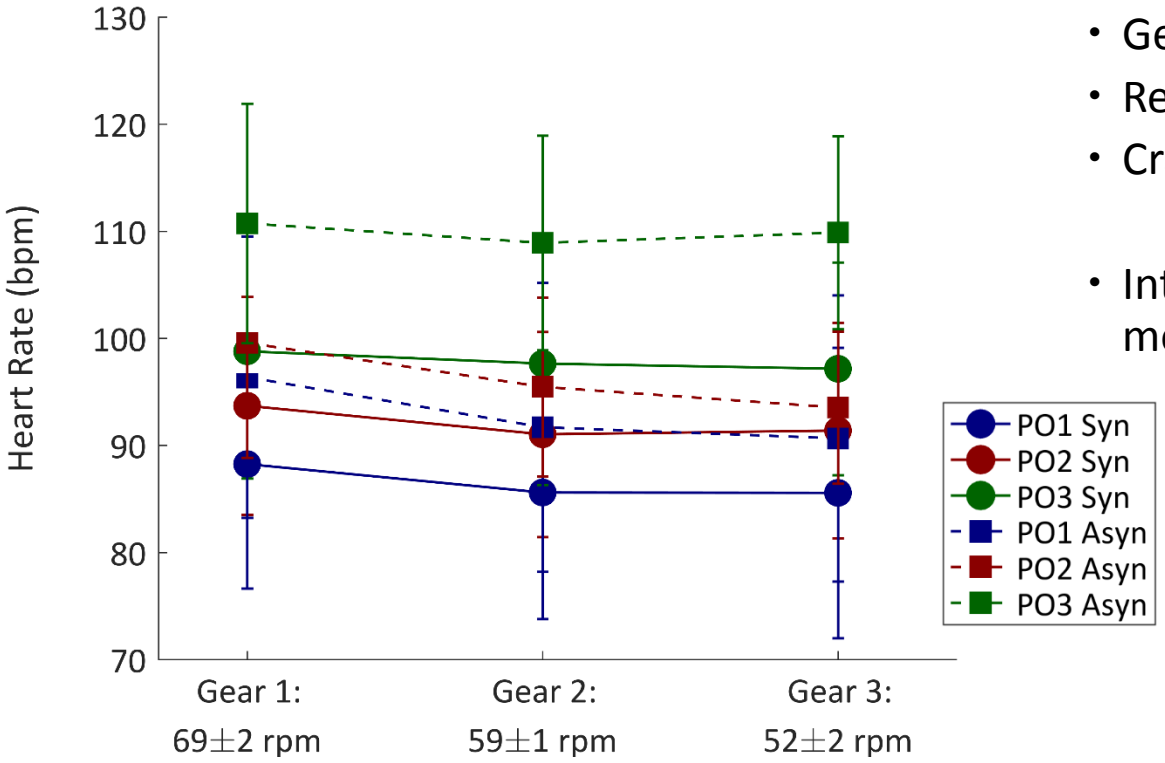
- Significant effect of:
  - Gear (P<0.001; η^2_p=0.59)
  - Resistance (P<0.001; η^2_p=0.91)
  - Crank mode (P<0.001; η^2_p=0.83)
  - Interaction effect resistance and crank mode (P=0.004; η^2_p=0.46)

Effect on oxygen consumption



- Significant effect of:
  - Gear (P<0.001; η^2_p=0.75)
  - Resistance (P<0.001; η^2_p=0.90)
  - Crank mode (P<0.001; η^2_p=0.76)
  - Interaction effect gear and crank mode (P=0.004; η^2_p=0.47)
  - Interaction effect gear and crank mode (P=0.002; η^2_p=0.51)

Effect on heart rate



- Significant effect of:
  - Gear (P=0.003; η^2_p=0.63)
  - Resistance (P<0.001; η^2_p=0.74)
  - Crank mode (P<0.001; η^2_p=0.77)
  - Interaction effect gear and crank mode (P=0.019; η^2_p=0.36)

Causes effects

- Added resistance is more straining due to higher propulsion force
  - By changing gear
  - By adding weight to pulley system
  - Force is more effective applied with added resistance

- In the asynchronous mode steering moments need to be controlled
  - Stabilization of the trunk needed

Bafghi HA, de Haan A, Horstman A, van der Woude L. Biophysical aspects of submaximal hand cycling. Int J Sports Med. 2008;29: 630–638. doi:10.1055/s-2007-989416
Dallmeijer AJ, Ottjes L, de Waardt E, van der Woude LHV. A physiological comparison of synchronous and asynchronous hand cycling. Int J Sports Med. 2004;25: 622–626. doi:10.1055/s-2004-817879
van der Woude LH, Horstman A, Faas P, Mechielsen S, Bafghi HA, de Koning JJ. Power output and metabolic cost of synchronous and asynchronous submaximal and peak level hand cycling on a motor driven treadmill in able-bodied male subjects. Med Eng Phys. 2008;30: 574–580. doi:S1350-4533(07)00132-4

Limitation

- Power differences between synchronous and asynchronous handcycling
  - Influence on mechanical efficiency calculation

Future plans

- Compare the forces/steering moments around the front fork axis for synchronous vs asynchronous mode
- Measure EMG
- Model handcycle movements

Thank you for your attention

- For more information:
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  - Research gate project: The fundamentals of daily handcycling

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