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This presentation will begin shortly...

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The AnyBody Modeling System™

- Full-body musculoskeletal simulations for activities of daily living
- Muscle and joint force computation + many other features
- Unprecedented model detail and validity

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Today's webcast presentation: Physiological Responses to Bicycle Design

Presenter

Ernst Albin Hansen, Ph.D
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Physiological responses to bicycle design

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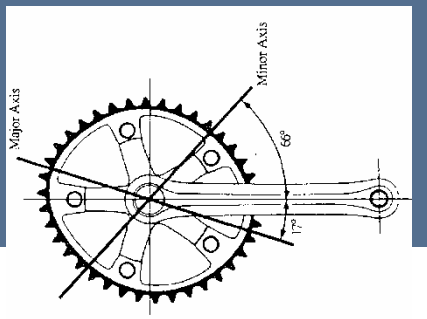

Journal of
PHYSIOLOGICAL
ANTHROPOLOGY

Effect of Chain Wheel Shape on Crank Torque, Freely Chosen Pedal Rate, and Physiological Responses during Submaximal Cycling

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J Physiol Anthropol 28(6): 261–267, 2009

Sports equipment design

Physiological/ biomechanical response

E.g. movement kinetics and kinematics, muscle activity, and energy turnover

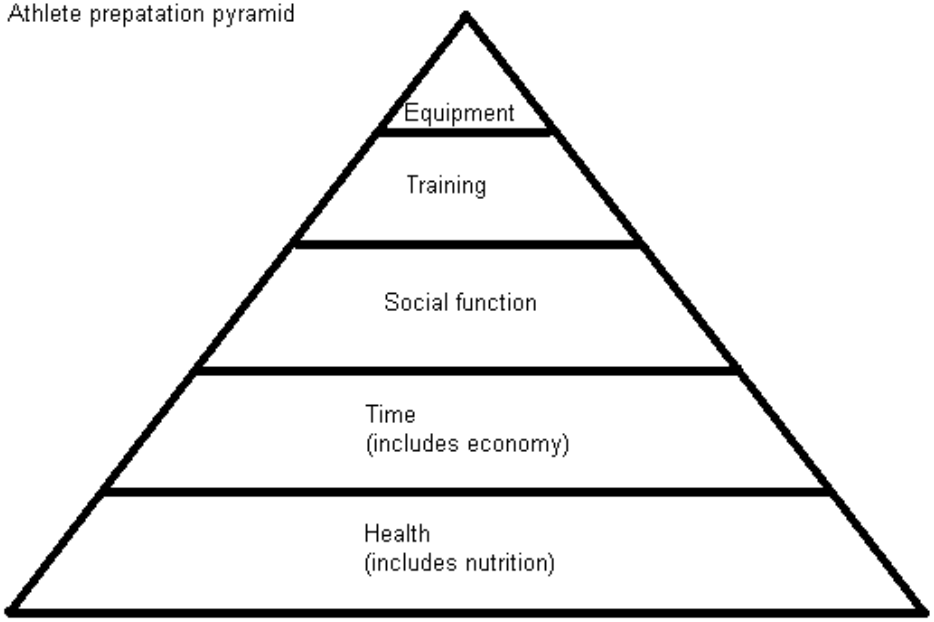
Psychological response

E.g. perceived exertion, comfort, and motivation

Performance

E.g. time to complete a distance and power output (sport) or comfort at a certain energy turnover and adherence (fitness)

Athlete prepatation pyramid



Cycling

Performed in sport, recreation, and rehabiliation

Bicycles

UCI rules have impact on design of bicycles for the commercial market

Examples of variables that have been changed in efforts to design effective bicycles

- Crank length
- Wheels
- Chain wheel shape

Non-circular chain wheels are (still) used in elite cycling

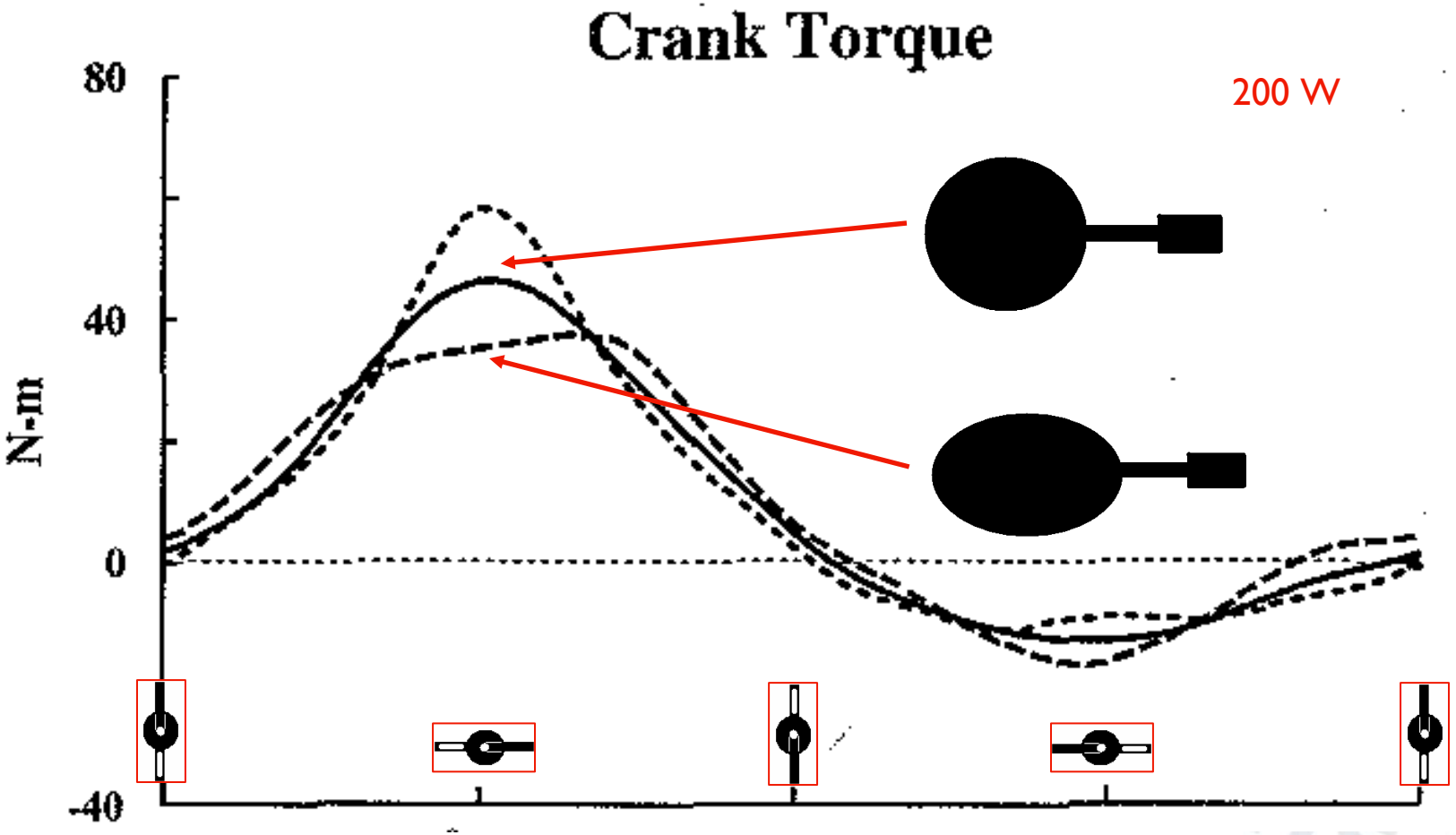
Bobby Julich

Olympic bronze medal, individual time trial, Athens, 2004

Major Taylor

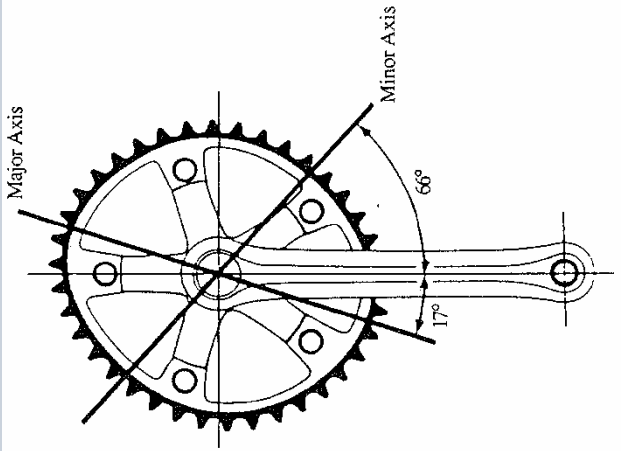
World champion, 1899

An elliptical chain wheel can reduce peak crank torque

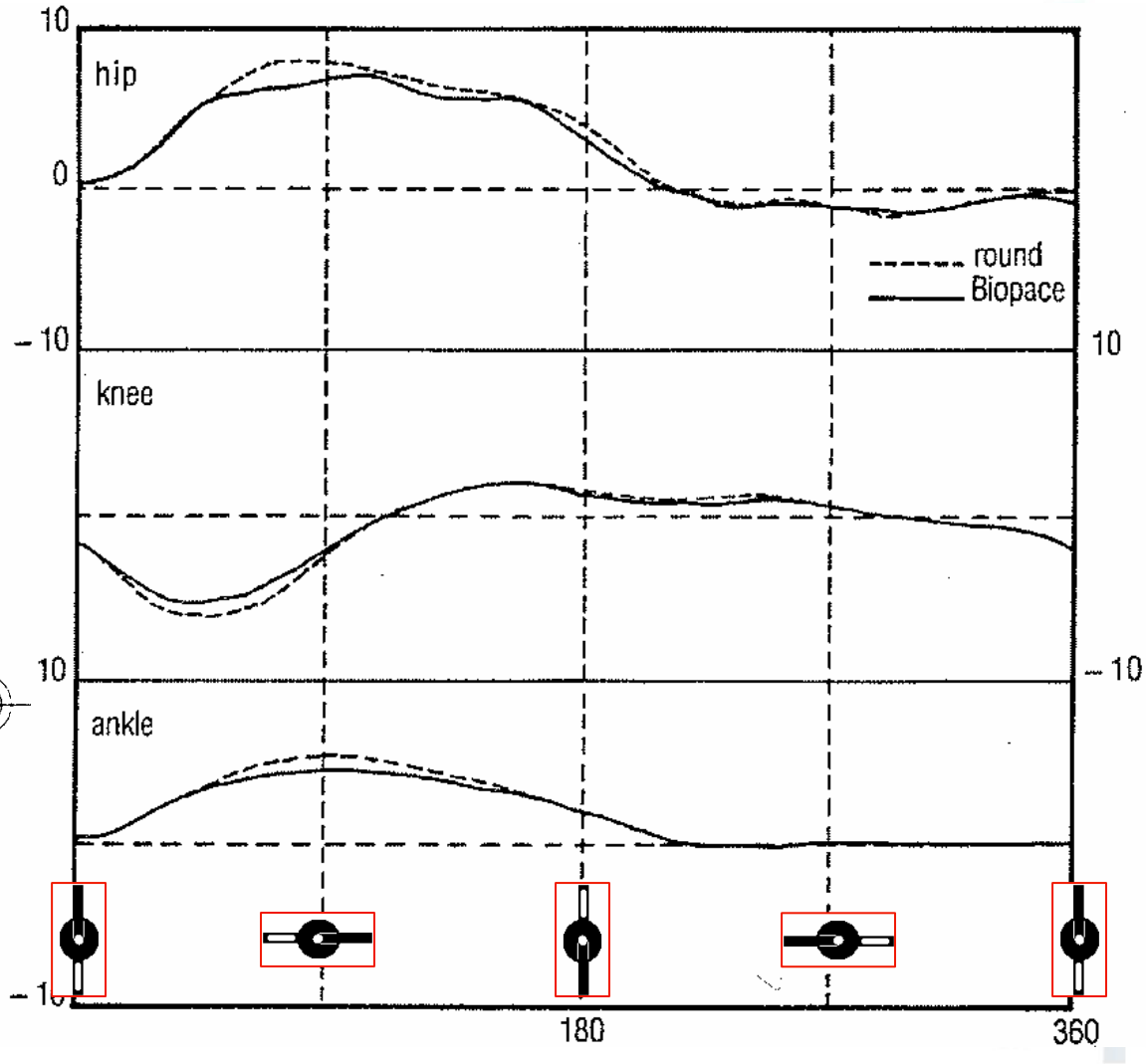


Neptune & Herzog (2000)

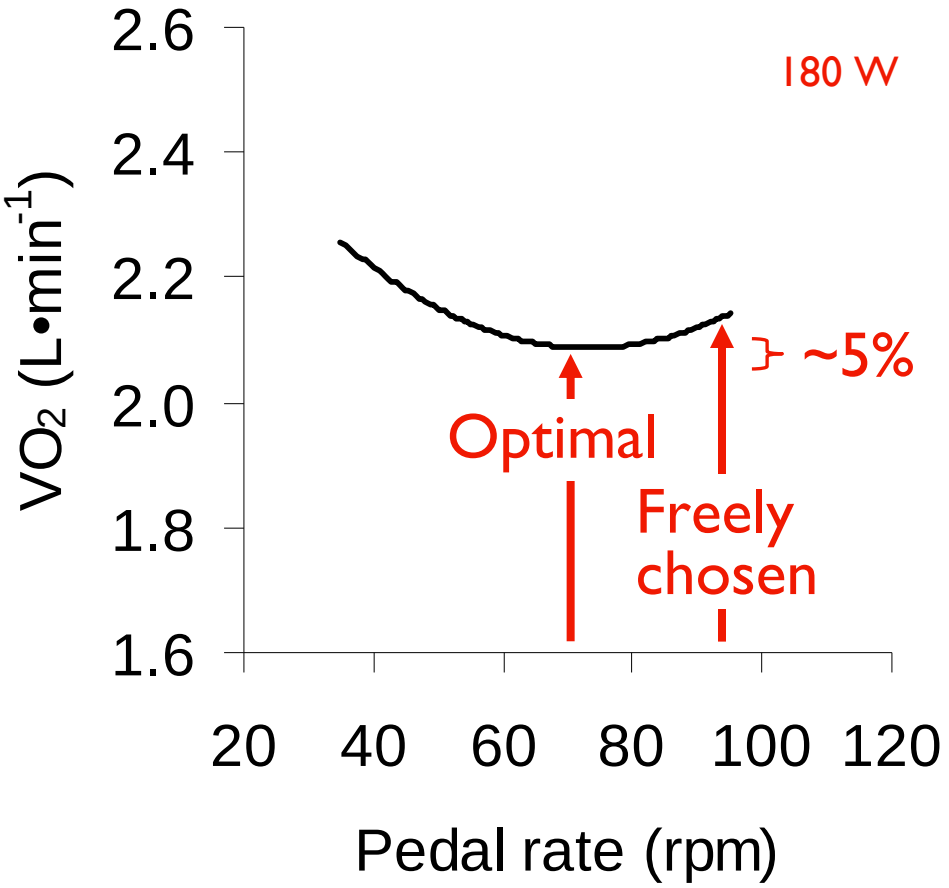
The Biopace chain wheel reduces peak joint torques



Okajima (1983)
Bike Tech

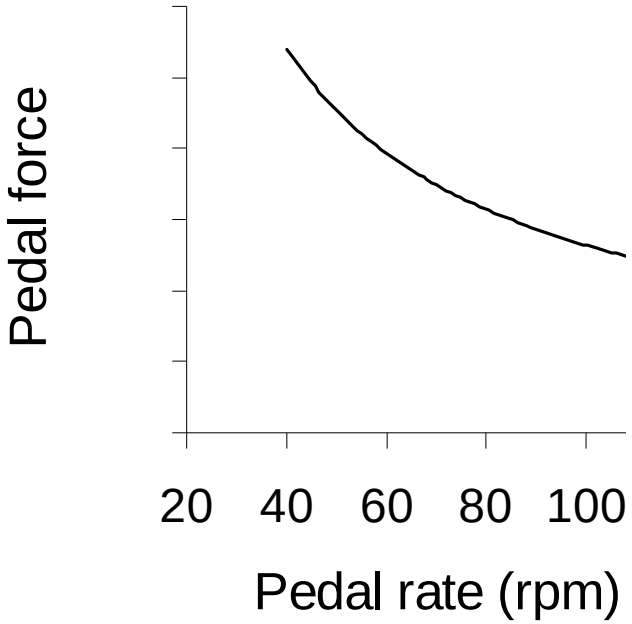


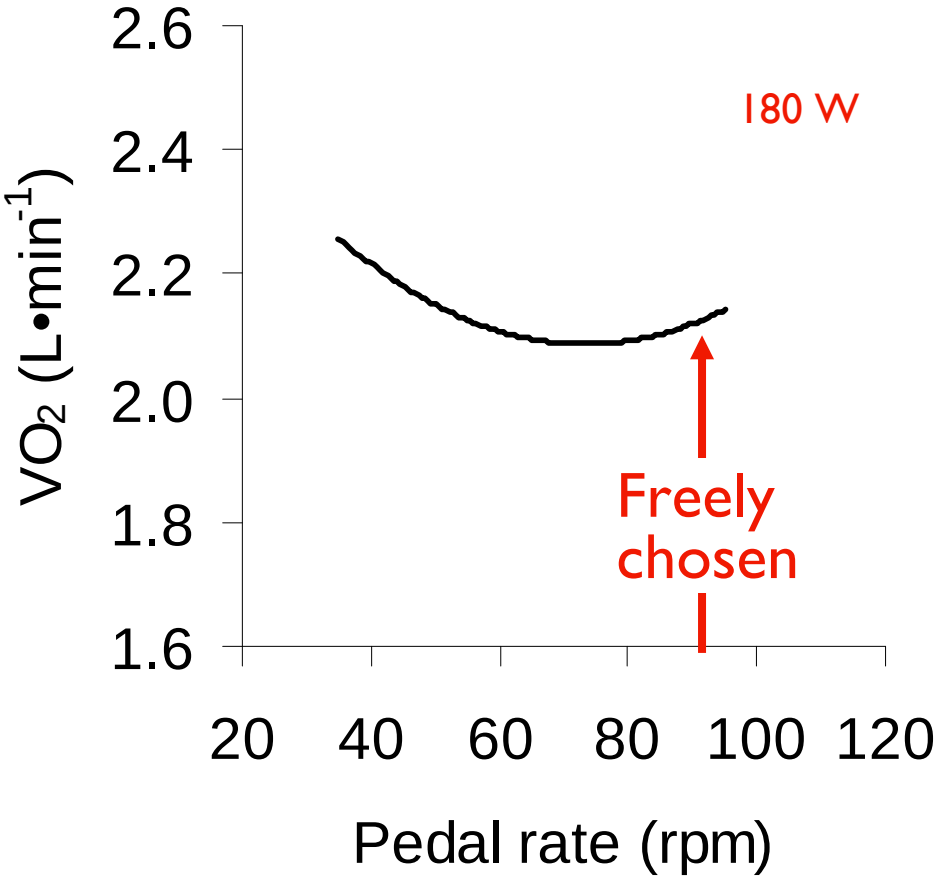
The freely chosen pedal rate is high and inefficient



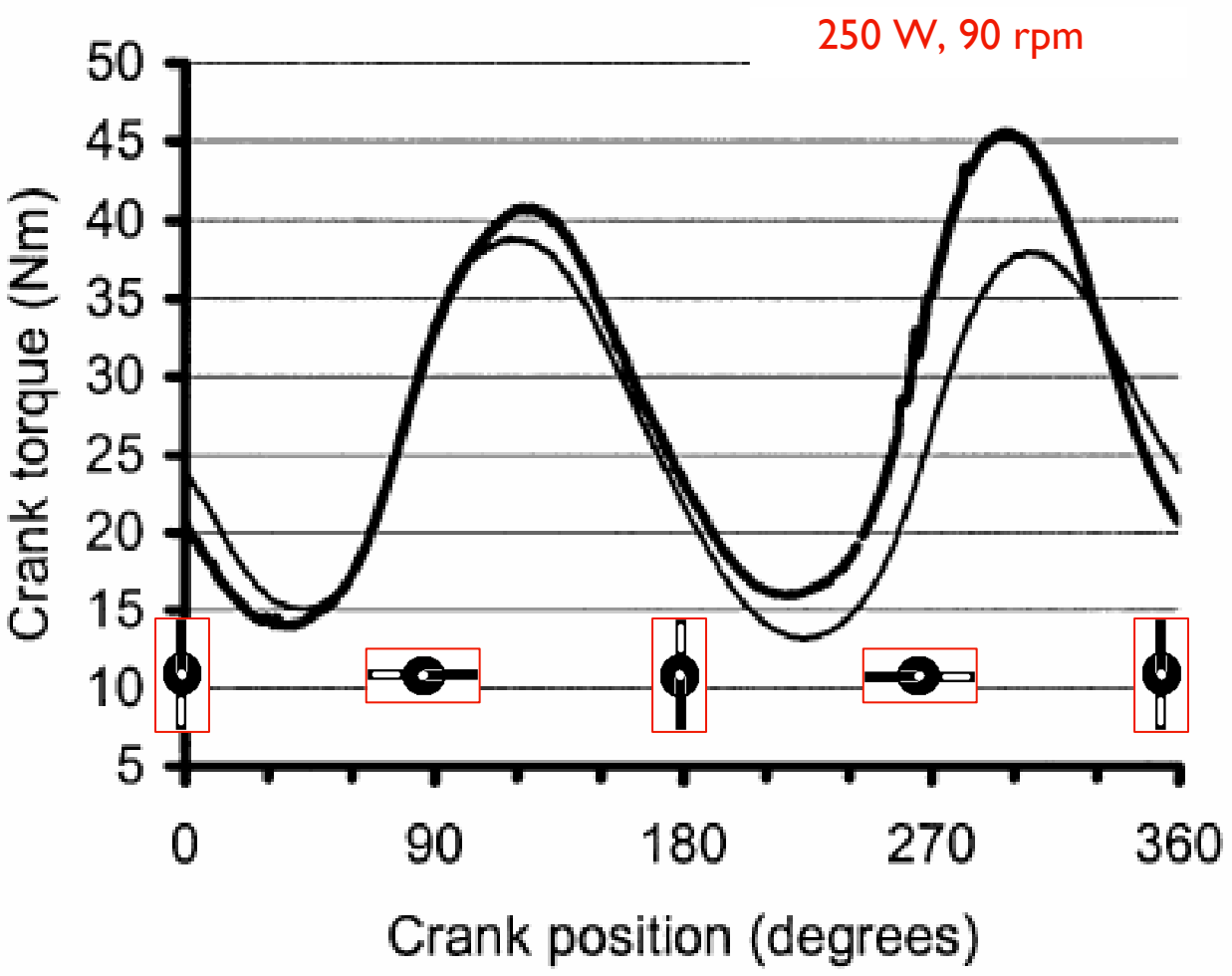
Nielsen et al. (2004)

It may be the perception of force that causes subjects to choose a high and inefficient pedal rate





A reduced peak crank torque has been suggested to cause a lower freely chosen pedal rate



Hansen et al. (2002)

Aim

Compare biomechanical and physiological responses during submaximal cycling with a non-circular and a circular chain wheel

Hypothesis

Biopace vs. circular chain wheel:

1) Peak crank torque ↓
   (at a fixed pedal rate)

   ↓

2) Pedal rate ↓ and VO_2 ↓
   (at freely chosen pedal rate)

Methods

- Ten trained cyclists (Peak VO_2 > 60 ml kg^{-1} min^{-1})
- 10 min cycle bouts at fixed and freely chosen pedal rates (180 W)
- 52T Biopace and circular chain wheels (randomised order)

Measurements

At fixed pedal rate: Crank torque profile characteristics

At freely chosen pedal rate: Pedal rate, VO_2, and blood lactate concentration ([La])

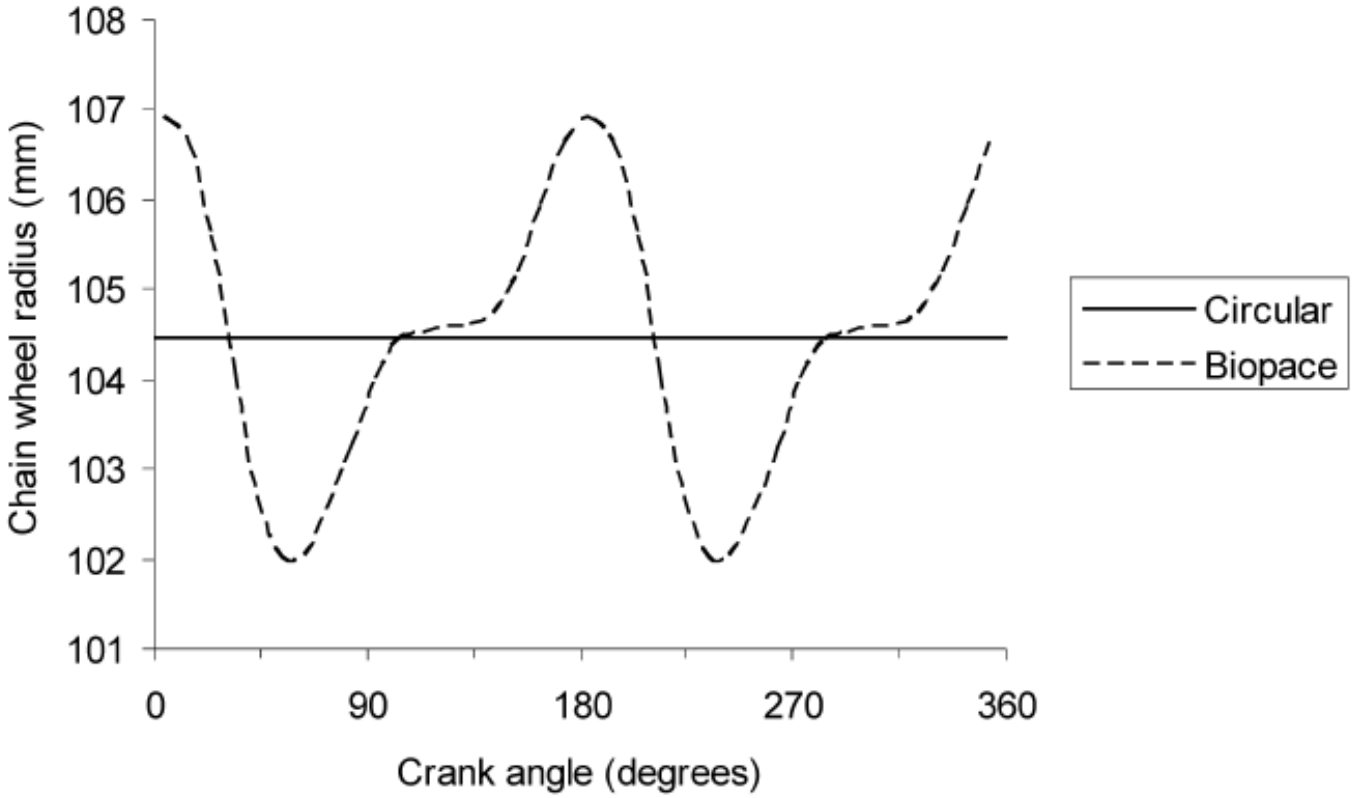
Results & discussion

At fixed pedal rate (90 rpm)	Circular	Biopace
T_{Peak} (Nm)	29.0±2.6	29.3±2.0
T_{Nadir} (Nm)	4.5±1.3	4.7±0.9
Crank angle at T_{Peak} (°)	89±8	90±9

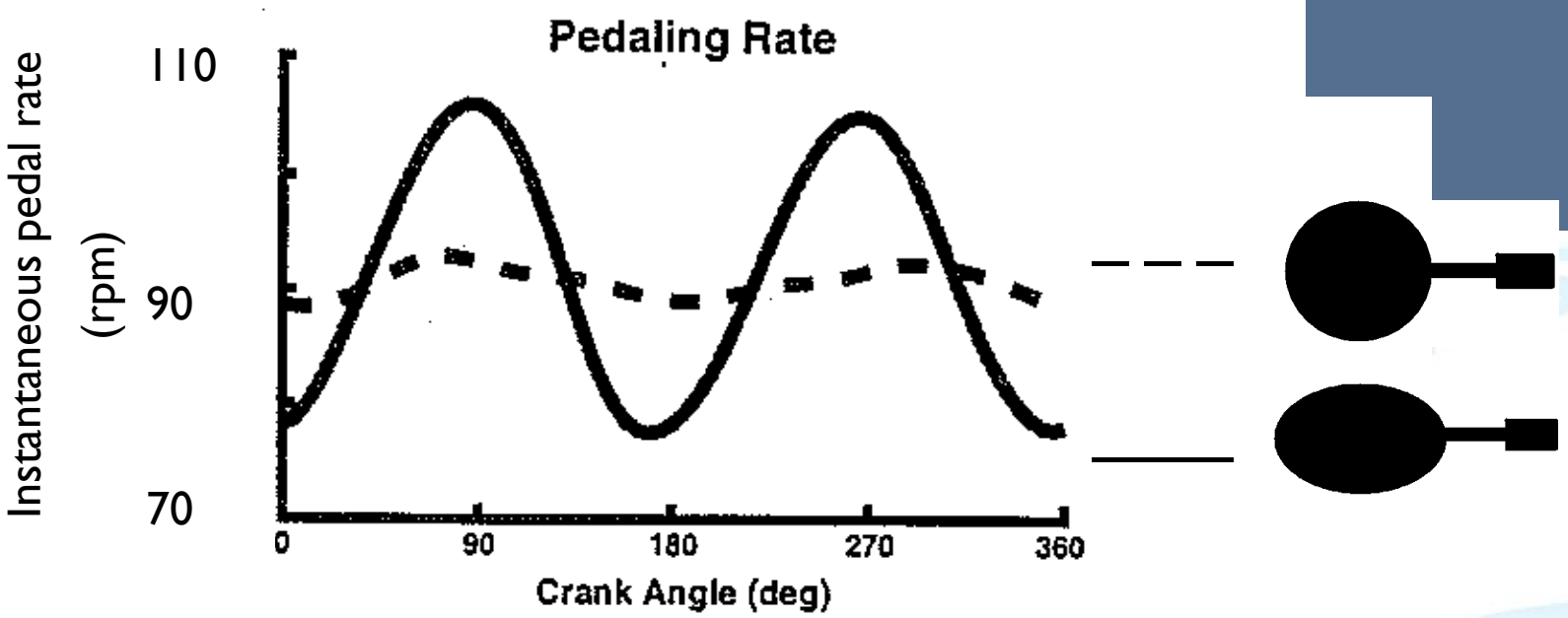
At freely chosen pedal rate

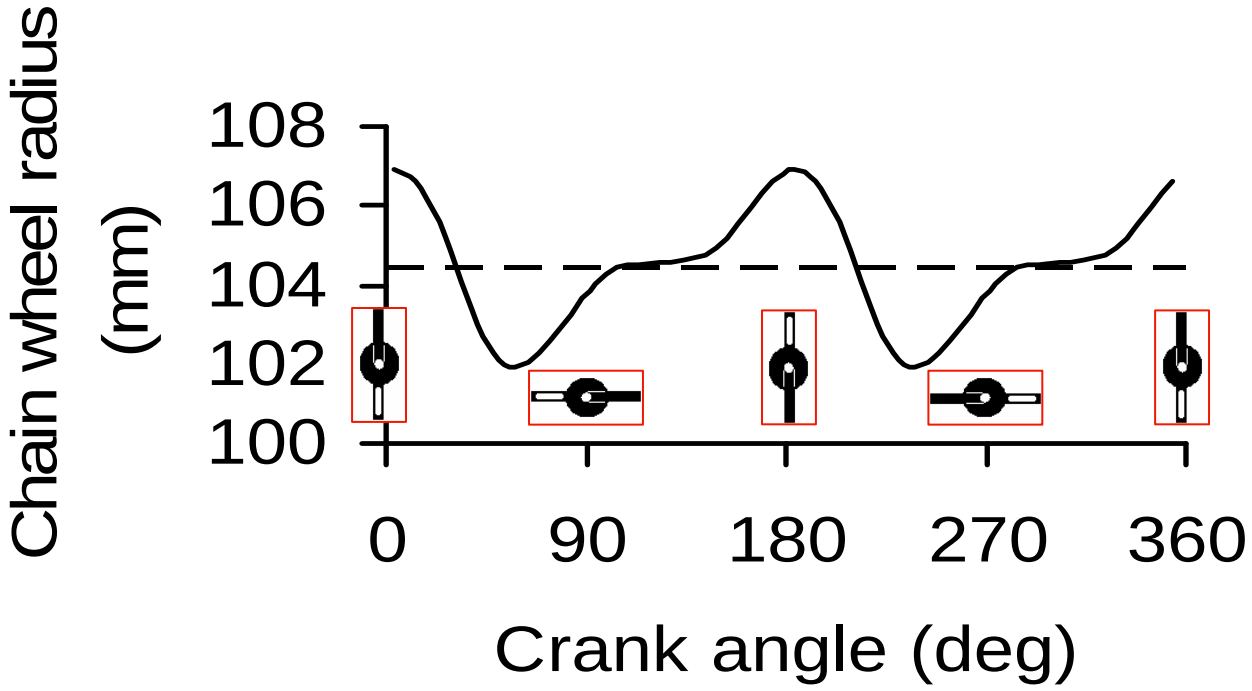
	Circular	Biopace
Freely chosen pedal rate (rpm)	93±4	93±6
VO_2 (l min^{-1})	2.15±0.08	2.13±0.09
Respiratory exchange ratio	0.91±0.05	0.91±0.06
[La] (mmol l^{-1})	0.9±0.4	0.7±0.2*

*Different from circular ($p<0.05$)



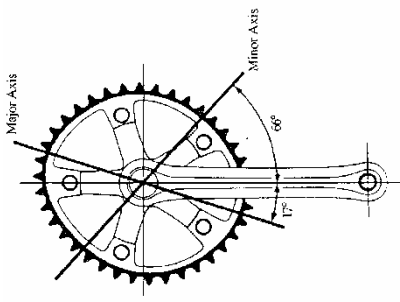
Neptune & Herzog (2000)

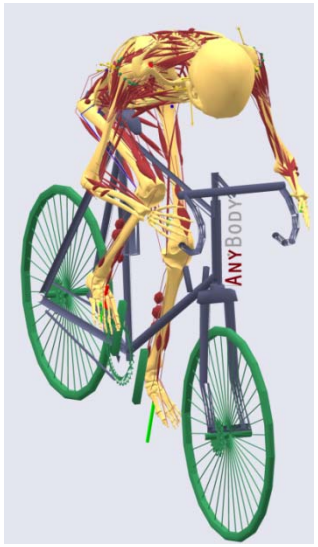




Biopace, 52T

Circular, 52T

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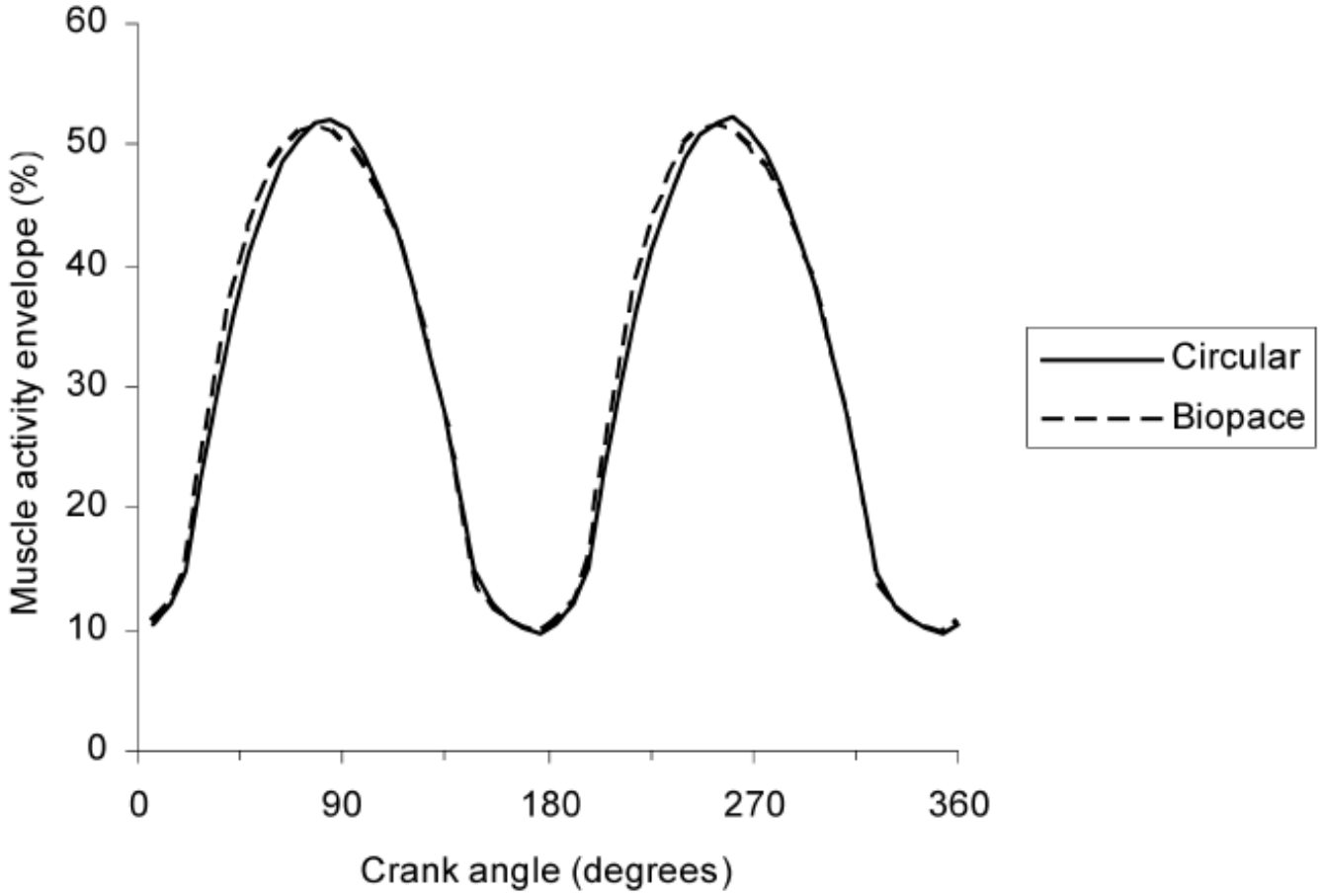

Muscle activity envelope (%)
60
50
40
30
20
10
0
0
90
180
270
360
Crank angle (degrees)
Circular
Biopace

A suggested explanation of the smaller blood lactate concentration during cycling with the Biopace chain wheel:

1. Decreasing chain wheel radius from top dead centre to approx. 60 ° crank angle

↓

2. Larger crank velocity near the angle where peak crank torque is produced

↓

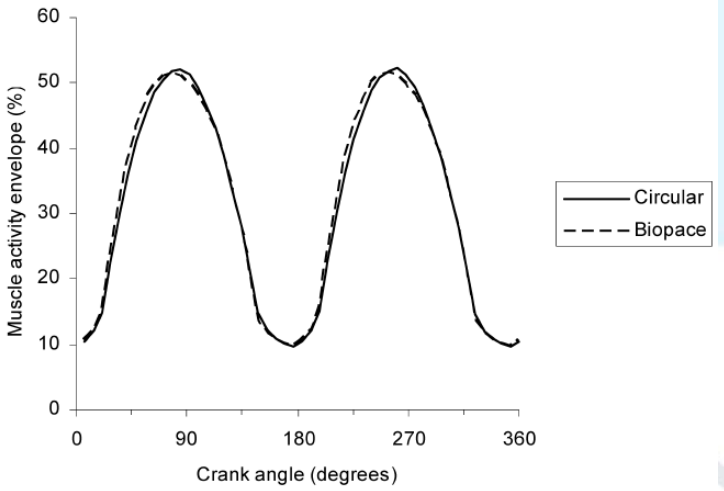
3. Larger non-muscular contribution to peak crank torque production from kinetic energy stored in the leg

↓

4. Less muscle activity near the angle where peak crank torque is produced

↓

5. Less fast twitch muscle fibre involvement



Conclusions

1. The two initial hypotheses were rejected. That is, the Biopace chain wheel neither reduced peak crank torque (at preset pedal rates), nor did it cause a reduced freely chosen pedal rate and oxygen uptake (energy turnover)

2. Blood lactate concentration was lower during submaximal cycling with the Biopace chain wheel

3. The AnyBody simulation model showed that the altered chain wheel shape, all other things being equal, may slightly change the muscle activity pattern and this might contribute to explain the experimental findings (of lower blood lactate concentration)

Some perspectives

- Combining carefully applied traditional methods within exercise physiology and advanced biomechanical musculoskeletal simulation models allows us to gain novel insight into so far unsolved problems

- Simulation models are helpful in our studies of the effect of even small changes in bicycle design

- This can help us in our efforts to optimize various aspects of e.g. bicycle design on smaller margins compared to previously

Acknowledgements

Aalborg University
Norwegian School of Sport Sciences
University of Southern Denmark

Thank you!

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Q&A Session

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