Ischaemic Preconditioning To Enhance Sport Performance:

“Waste of time or no time to waste?”

Prof. Dick Thijssen
Liverpool John Moores University
Radboud university medical center
Overview

“Doctor, is this the normal procedure?”

“Trust me, it has great exercise benefits!”

Sport performance

Mechanisms

Exercise preconditioning
Performance: *benefits of preconditioning*

**Design:** cross-over design (IPC vs control)

**Subjects:** 15 healthy young

**IPC:** Leg 3 x 5 Bilateral (local)

Workload: 1.6%

1. De Groot *Eur J Appl Physiol* 2010
**Performance:** benefits of preconditioning

**Design:** cross-over design (IPC vs control)

**Subjects:** 17 healthy young

**IPC:** Leg 3 x 5 Bilateral (local)

---

**Control**

**IPC prior to exercise**

**Cycling, then IPC, then max test**

No change in $O_2$ uptake, but improved workload

---

Yes: 2 papers
No: 7 papers

Yes: 5 papers
No: 2 papers

---

Performance: *type of exercise*

Types of exercise

1. Anaerobic – alactic (sprint)
2. Anaerobic – lactic (mixed)
3. Aerobic (endurance)

1. McArdle *Exercise Physiol* 2016
Performance: *type of exercise – anaerobic, alactic*

**Design:** cross-over design (IPC vs placebo vs control)

**Subjects:** 17 healthy young

**IPC:** Leg 4 x 5 Bilateral (local)

**Exercise:** 12-repeated max

**Significant improvement, but similar to placebo**
Performance: type of exercise – anaerobic, lactic

Design: cross-over design (IPC vs control)
Subjects: 14 rowers
IPC: Arm 4 x 5 Unilateral

Design: cross-over design (IPC vs control)
Subjects: 11 swimmers (elite)
IPC: Arm 4 x 5 Unilateral

186.5±3.6 s to 185.7±3.6 s
↑ 0.5%

110±16 m to 119±14 m
↑ 7%

Significant improvement

4. Patterson MSSE 2015
Performance: type of exercise – anaerobic, lactic

Design: cross-over design (IPC vs SHAM)
Subjects: 18 National level swimmers
IPC: Arm 4 x 5 unilateral

Significant improvement, especially in swimming

Enhanced exercise performance

1.11%
0.7 s (0.05-1.35 s)
Performance: *type of exercise – aerobic*

**Design:** cross-over (IPC vs SHAM)
**Subjects:** 13 trained men
**Exercise:** 5-k running
**IPC:** Legs 4 x 5 bilateral

---

**Design:** cross-over (IPC vs SHAM vs CT)
**Subjects:** 15 trained men
**Exercise:** supramaximal running
**IPC:** Legs 4 x 5 bilateral

---

**Significant improvement?**
Performance: type of exercise

Types of exercise

1. Anaerobic – alactic (sprint) ✗
2. Anaerobic – lactic (mixed) ✓
3. Aerobic (endurance) ✓❓

OK….it may work…..but……

1. Where to apply IPC? (remote vs local)
2. When to apply IPC? (early vs late)
3. How frequently apply IPC? (‘dose-response’)

1. McArdle Exercise Physiol 2016
Performance: *IPC vs RIPC*

**Design:** cross-over (IPC vs SHAM)
**Subjects:** 13 trained men
**Exercise:** handgrip exercise
**IPC:** Legs 3 x 5 bilateral

RIPC seems to work

- Swimmers (arms only)
- Rowers (arms only)

---

1. Barbosa *SJMSS* 2015  
2. Seeger *JSMS* 2017  
3. Cocking *In Review* 2017
Performance: *Early vs late preconditioning*

**Design:** cross-over (1h vs 2h vs 24h)

**Subjects:** 15 trained swimmers

**Exercise:** 50-m swim

**IPC:** Legs+arms 4 x 5 bilateral

Late IPC seems to work

5-km: R=0.67 for early (30-min) vs late (24-h)
Performance: *Dose-response relationship*

**Design:** cross-over (sham vs IPC vs doses)
**Subjects:** 15 trained runners
**Exercise:** 5-km run
**IPC:** Legs 4 x 5 bilateral

No dose-response?

1. Cocking *In Review* 2017
Performance: summary

Types of exercise

1. Anaerobic – alactic (sprint)
2. Anaerobic – lactic (mixed)
3. Aerobic (endurance)

OK….it may work…..but……

1. Remote and local IPC
2. Early and late IPC
3. Dose-response relation

FUTURE WORK
Practical guidelines for athletes!!

How does it work?
Mechanisms: Oxygen uptake kinetics

Peak oxygen uptake: similar

Submaximal oxygen uptake: similar

Oxygen uptake kinetics: similar
Mechanisms: *Muscle contraction kinetics*

Higher contraction and relaxation rates

More muscle activity

1. Barbosa *SJMSS* 2015   2. Cruz *JAP* 2015
Mechanisms: *Lactate kinetics*

**Design:** cross-over design (IPC vs SHAM)

**Subjects:** 13 moderately trained males

**IPC:** Leg 4 x 5 Bilateral (LOCAL)

---

Lower lactate accumulation

No difference in peak lactate!!!
Mechanisms: Blood flow kinetics

Design: cross-over (IPC vs SHAM)
Subjects: 15 healthy males
Exercise: cycling exercise

More rapid blood flow kinetics

1. Kido Physiol Rep 2015
Mechanisms: reduced vascular injury

**Design:** cross-over design (IPC vs SHAM)

**Subjects:** 13 moderately trained males

**IPC:** Leg 4 x 5 Bilateral (REMOTE)

RIPC prevents exercise-induced vascular injury?

RIPC prevents exercise-induced vascular injury?

1. Bailey *AJP* 2012
Mechanisms: *Pain sensation*

**Design:** cross-over design (IPC vs SHAM)
**Subjects:** 13 trained males
**Exercise:** supramaximal cycling

**Design:** cross-over (IPC vs SHAM)
**Subjects:** 14 healthy males
**Exercise:** post-exercise muscle ischemia

**Lower pain sensation?**
## Performance: summary

### Types of exercise

<table>
<thead>
<tr>
<th>Anaerobic – alactic (sprint)</th>
<th>Anaerobic – lactic (mixed)</th>
<th>Aerobic</th>
</tr>
</thead>
</table>

### Mechanisms

<table>
<thead>
<tr>
<th>Oxygen kinetics</th>
<th>Muscle kinetics</th>
</tr>
</thead>
</table>

## FUTURE WORK

Better understanding of (molecular) mechanisms.

Reduced vascular injury.... Does exercise have preconditioning effects?

### Remote and local IPC

<table>
<thead>
<tr>
<th>Early and late IPC</th>
<th>Dose-response relation</th>
</tr>
</thead>
</table>

1. McArdle *Exercise Physiol* 2016
Exercise preconditioning: reduced cardiac injury

**Design:** Cross-over design (1. IPC, 2. interval exercise)

**Subjects:** 12 healthy subjects

**Measurements:** infarct size (animals)

---

25-min perfusion (Control, IPC, Exercise)
40-min ischemia
120-min reperfusion

1. Michelsen *Bas Res Cardiol* 2013

Radboudumc
Exercise preconditioning: *reduced cardiac injury*

Interval exercise has *IPC-like* effects to prevent IR-injury

Effects are mediated through a blood-borne substance
Exercise preconditioning: prevents vascular injury

**Design:** Cross-over design (1. control, 2. endurance exercise, 3. interval exercise)

**Subjects:** 14 healthy subjects

**Measurements:** FMD pre/post IR-injury

**Acute effects exercise:** Has exercise IPC-like effects?

- **Control:** 45-min rest
- **Endurance:** 43-min exercise
- **High-intensity interval:** 27-min exercise (isocaloric)

1. Seeger *AJP Heart Circ Physiol* 2015
Mechanisms: exercise prevents vascular injury

Exercise has IPC-like effects to prevent IR-injury, which may depend on the type of exercise.

FUTURE WORK: do these effects also contribute to protection against cardiovascular events?

1. Seeger AJP Heart Circ Physiol 2015
Cardioprotection: *exercise preconditioning reduces risk*
Cardioprotection: *exercise preconditioning reduces risk*

1. Van den Munckhof *AJP-Heart* 2013  
2. Maessen *AJP-Heart* 2017

**Lifelong exercise prevents ischaemic injury with ageing**

**Older age:**
- Larger ischaemic injury
- No effect preconditioning

1. Van den Munckhof *AJP-Heart* 2013  
2. Maessen *AJP-Heart* 2017
Relevant for athletic performance

1. Ischaemic preconditioning *improves* aerobic-anaerobic sport performance.

2. Related to improved metabolic and vascular *kinetics*.

Relevant for all

Exercise preconditioning *protects* against cardiovascular (ischaemic) events.
Thank you for listening

Liverpool John Moores University:
  Prof. Danny Green
  Prof. Nigel Cable
  Prof. Helen Jones
  Dr. Ellen Dawson
  Dr. Howard Carter
  Dr. Tom Bailey
  Joseph Maxwell

University of Western Australia:
  Prof. Danny Green

Radboud University:
  Prof. Maria Hopman
  Prof. Niels Riksen
  Prof. Gerard Rongen
  Prof. Paul Smits
  Dr. Joost Seeger
  Inge van den Munckhof
  Dr. Martijn Maessen