Endurance training improves tolerance to mental exertion in untrained individuals

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Background

Prior mental exertion

leads to

↓ cognitive performance[1,2]

↓ physical performance[3]

1. Lorist et al., (2005). Brain Res Cogn Brain Res. 24(2): 199-205.
2. van der Linden et al., (2003). Acta Psychol. 113(1): 45-65.
3. van Cutsem et al., (2017). Sports Med. 47(8): 1569-88.

- Physical training can:
  - Improve physical performance & alleviate physical-fatigue
  - Improve learning (in children[1]) & reduce cognitive decline (in older[2]),

BUT

- Can physical training :
  - Improve cognitive performance (healthy young adults) & alleviate mentally-induced fatigue[‡]

1. Sibley & Etnier (2003). Ped. Ex. Sci. 15(3): 243-256.
2. Northey et al., (2018). Brit J Sports Med. 52: 154-160.

‡ Martin et al., (2016). PLoS ONE. 11(7): e0159907.

Aim

- investigate whether 4 weeks of endurance training could improve tolerance to mental exertion in untrained participants, &

- whether endurance training would improve cognitive performance

Method - participants

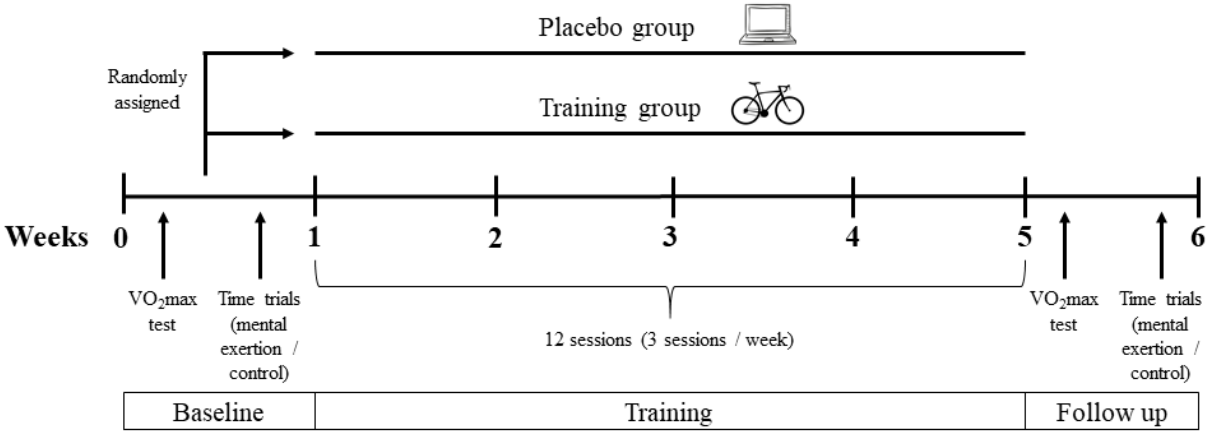
- Initially untrained participants (n=20) – largely University student cohort
- Group allocation randomised

	Training group (n = 10)	Placebo group (n = 10)	p
Females, n (%)	7 (70)	7 (70)	1.00
Age, y	27.6 (6.3)	27.5 (6.0)	0.97
Height, cm	169.4 (6.8)	169.5 (9.6)	0.98
Weight, kg	69.6 (18.4)	68.7 (14.3)	0.91
$VO_{2peak,}$ $ml \cdot min^{-1} \cdot kg^{-1}$	32.9 (6.9)	32.8 (5.6)	0.98
TT in control condition, m	6823 (715)	6762 (701)	0.85
TT difference (mental exertion - control), m	-246 (214)	-200 (156)	0.59

Note: Data are presented as mean (SD) or number of participants.

Table 1. Baseline characteristics of the study by group allocation.

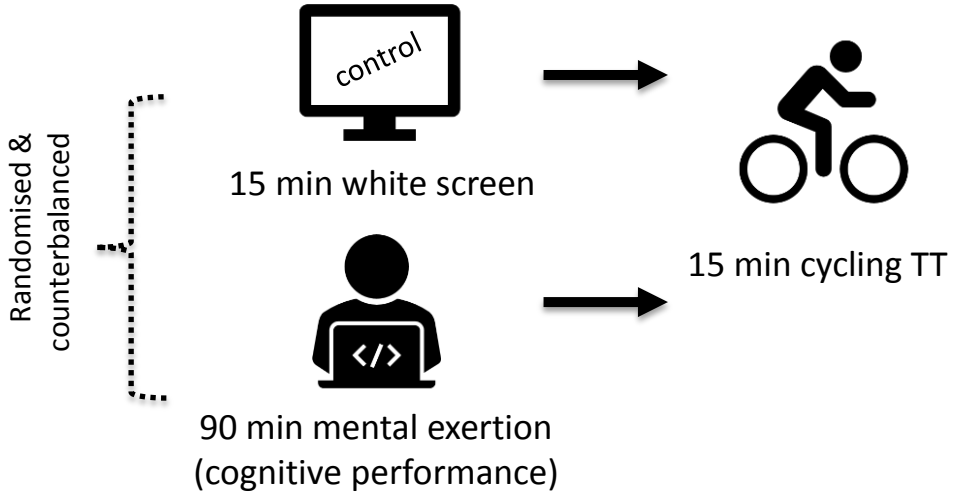
Method - design



- Physical training
  - cycle ergometer for ~ 3x1h/wk 1 x intervals; 20 min at 65-70%, plus 6 x 3 min at 85-90% peakHR,
    1 x threshold; 20 min at 65-70% followed by 40 min at 75-80%,
    1 x moderate; 60 min at 65-70%
- Placebo group
  - Equivalent time watching documentaries, participants asked to recall simple questions pertaining to content

Method - measures

Session 2 & 3 of
Baseline & Follow-up



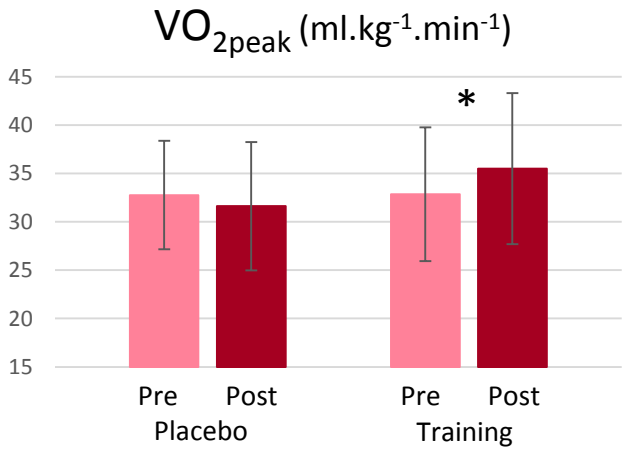
Indices of performance, heart rate, perceived exertion, workload & motivation assessed

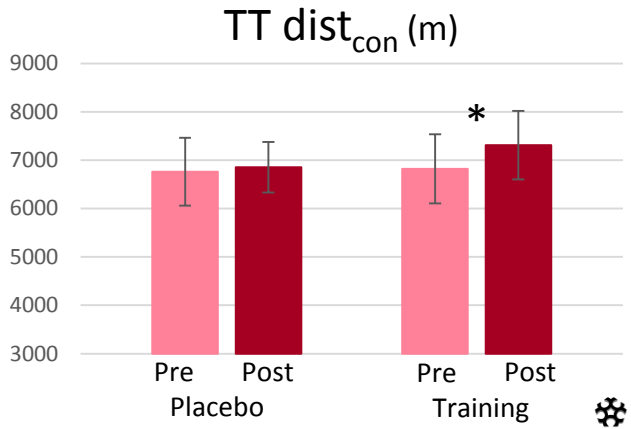
mental exertion task consisted of computerised cognitive tasks, assessing attention, working memory, response inhibition & task-switching

Results – training & fitness

Session	Heart rate, bpm	Power output, W	Cadence, rpm	RPE
1	126 (8)	71.8 (20.2)	71.0 (6.2)	13.2 (2.4)
6	146 (9)	91.2 (28.1)	73.1 (8.3)	15.1 (2.5)
12	145 (10)	99.8 (27.8)	75.1 (8.9)	14.5 (3.0)

Note: Data are presented as mean (SD)





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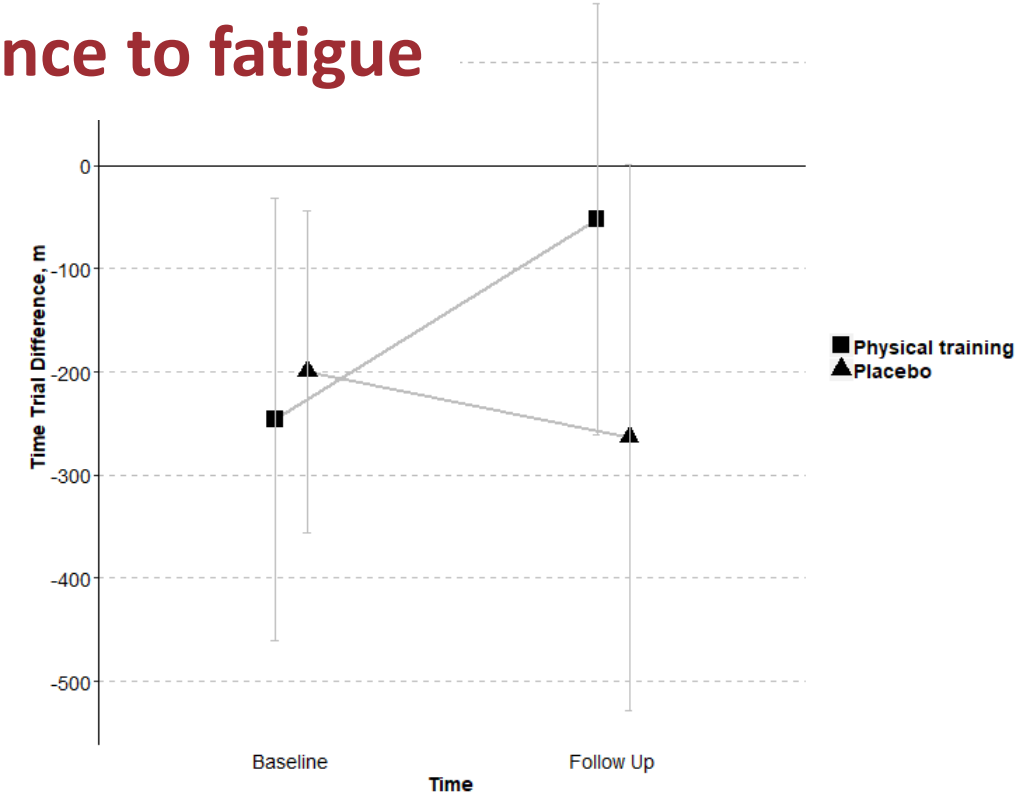
Results – resistance to fatigue

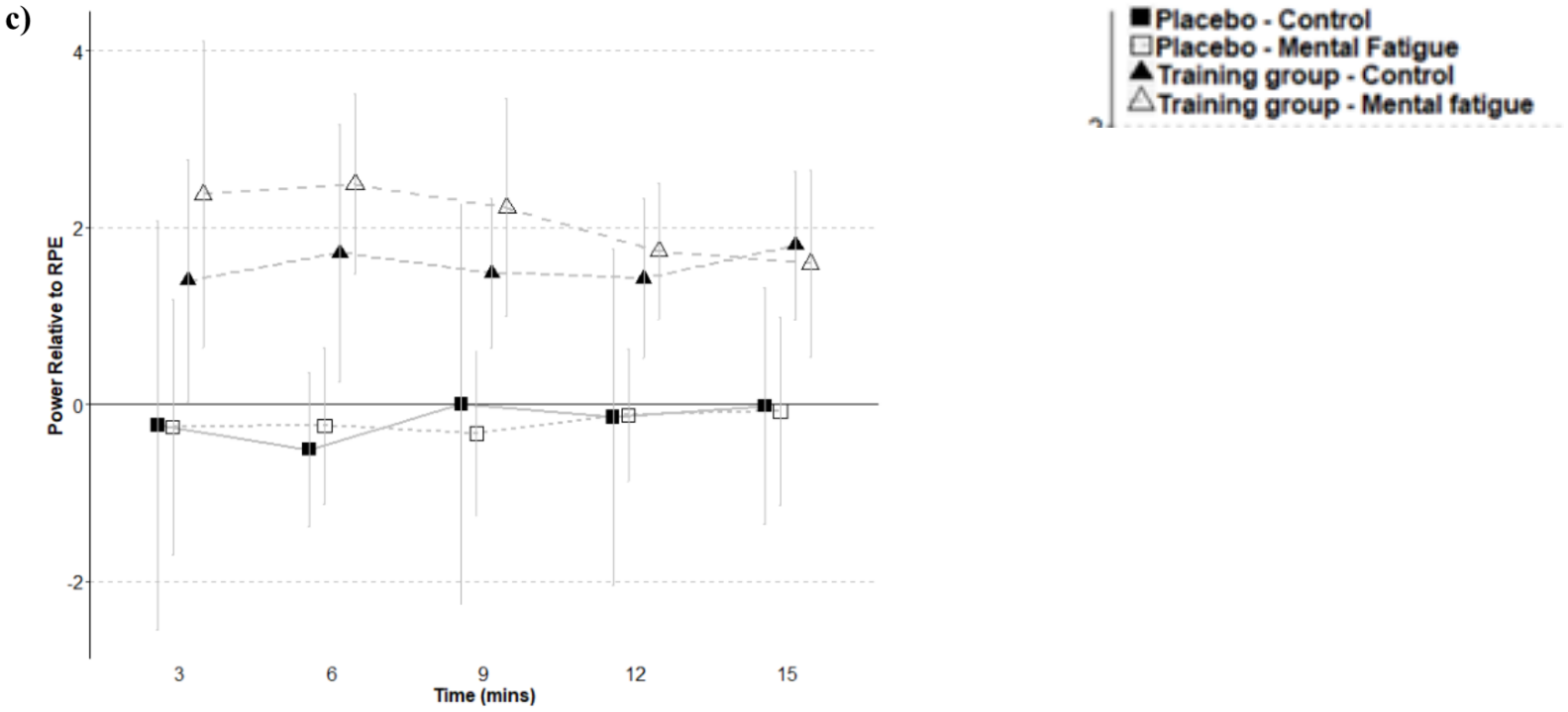


Physical training group increased TT distance following mental exertion task to greater extent than placebo group (b=264 m; 95% CI: 211 to 476; p=0.03). Linear mixed models utilising control task TT performance as a covariate.

Results – cognitive performance

	Task	Training group - Baseline	Control group - Baseline	Training group - Follow up	Control group - Follow up
Accuracy (%)	Flanker (1)	98.2 (1.5)	96.3 (3.2)	98.4 (1.5)	97.3 (4.2)
	Go/no-go	98.7 (2.0)	98.5 (1.2)	98.5 (1.2)	98.4 (0.9)
	Stroop	94.9 (2.0)	94.8 (4.5)	97.0 (2.1)	96.7 (1.8)
	Flanker (2)	98.8 (1.3)	97.1 (2.8)	98.2 (2.1)	96.2 (3.8)
Reaction time (ms)	Flanker (1)	423 (49)	429 (64)	413 (38)	427 (57)
	Go/no-go	813 (98)	857 (104)	825 (90)	866 (101)
	Stroop	819 (167)	811 (125)	812 (161)	769 (145)
	Flanker (2)	430 (52)	454 (49)	419 (42)	429 (65)
Other measures	Go/no-go omission	1.9 (2.9)	1.6 (1.1)	2.7 (1.9)	3.6 (2.4)
	Go/no-go commission	0.4 (0.5)	0.3 (0.7)	0.4 (1.0)	0.2 (0.6)
	Stroop false alarms	1.5 (4.4)	0.9 (1.3)	0.1 (0.3)	0.8 (1.1)
	Stroop lapses	6.9 (10.9)	5.3 (5.6)	4.4 (7.9)	3.3 (4.1)

Results – performance to effort?



Implications

Operators should be encouraged to **improve and/or maintain aerobic fitness** as reducing the impact of mental fatigue on subsequent tasks may improve work productivity and minimise errors

- Fitness for all operators
  - Resilience to mental exertion
  - Recovery from mental exertion
  - Suspect also cog. performance, but data not supportive here
- Our participant group – comparison to current military
  - Suspect little similar results, perhaps greater results given more stressful conditions under which cognitive control exhibited in military
- Raises Q's re targeted training interventions (e.g., combining cognitive/physical training stimuli)
- Mechanistically supportive of cognitive control overlap/training

Cognitive Control

- processes, or capacity, by which individuals manage goal-orientated behaviours (effort-reward decisions) against habitual tendencies or in the face of many choices.

(Norman and Shallice, 1986; Badre and Nee, 2018)

  - Attentional demands feel effortful
  - Reduced need when tasks demands are low, or automated (well-learned)
  - Present in novel situations

Cognitive Control in *military*

in regards to other cognitive domains, *cognitive control* is associated with:

- response selection and inhibition paradigms
  - Target/tactical identification in a complex environment
  - emotional regulation
- tasks demanding goal selection & maintenance (sustained attention; vigilance),
  - Staying focused
- and/or performance monitoring, task switching (working memory),
  - maintaining situational awareness and command

Decisions regarding whether to continue to engage in an action or behaviour are also consistent with effort-reward decision making [cognitive control] (Wittmann et al., 2016)

Conclusions

- 4 weeks endurance training ↑tolerance to mental exertion in untrained participants

- ability to tolerate mental exertion is trainable
- those in cognitively challenging occupations are likely to benefit from physical training

Acknowledgements

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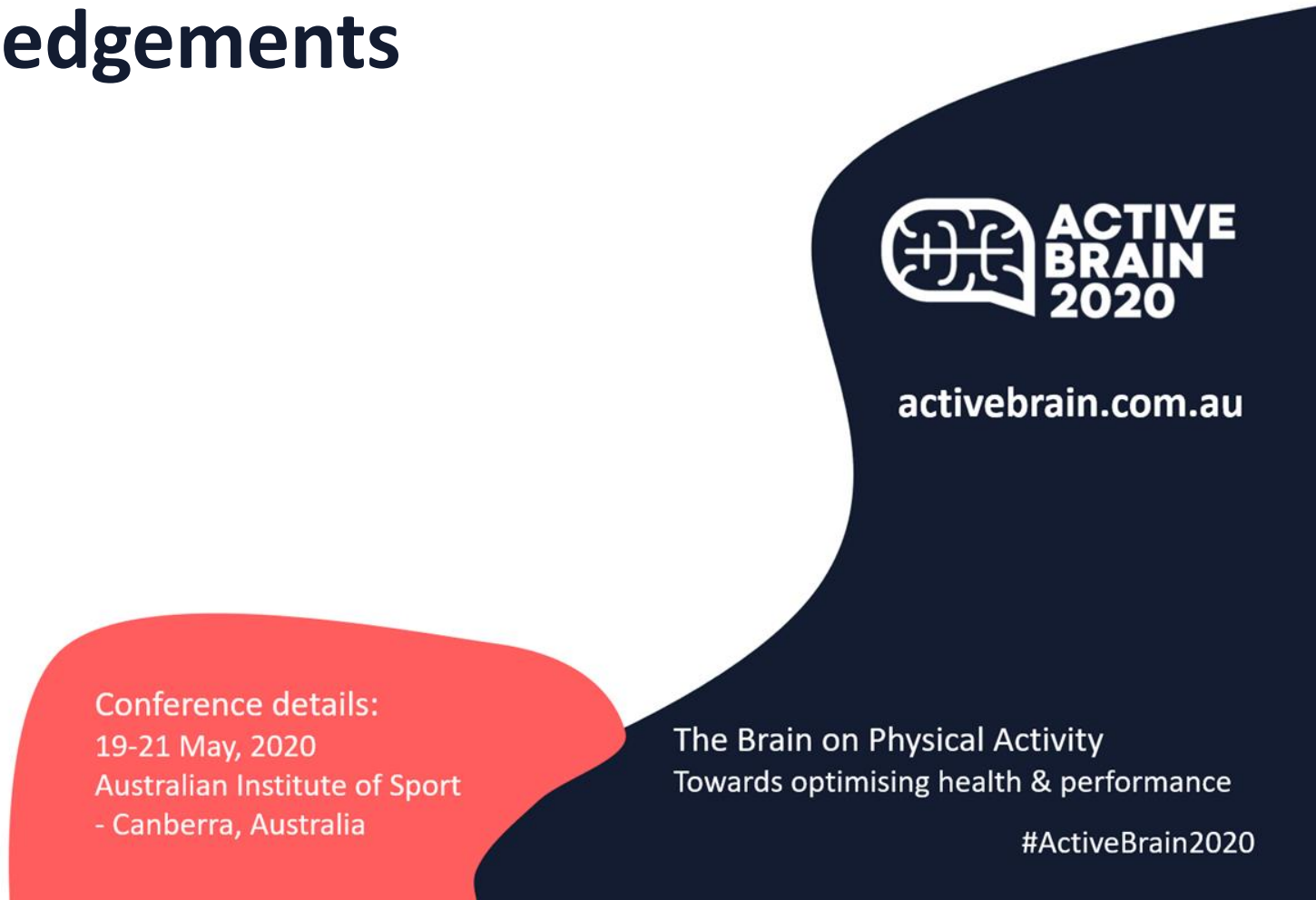

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