

Exercise and the Brain in Health & Disease

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Content

Health benefits of exercise
 Health benefits for the Brain
 Mechanisms for neurogenesis
 Exercise, Pollution & the Brain

- Bewegen als werk
- Bewegen op het werk
- Bewegen naar het werk



Health benefits of exercise

- Cardiovascular diseases
- Metabolic syndrome
- Obesity
- Diabetes
- Hypertension
- COPD
- Osteoarthritis
- Osteoporosis
-
- Stroke
- Depression
- Cognition
- Alzheimers disease
- Parkinsons disease
- Spinal cord injury
- ...



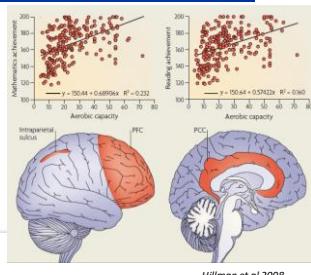
Exercise and Academic Performance

Aerobic Fitness

- Positive relation with academic performance
- BMI → Negative relation

Relevant neural networks

- Prefrontal Cortex
- Parietal/Posterior Cingulate Cortex



Physical Activity intervention

- N= 221
- 7-9yr
- 9 month intervention RCT (waiting list)
- PA : after school recreation & sports
- Measuring Brain Activity - ERP
- Accuracy & reaction time (executive control)



Hillman et al, 2014



Results

- Fitness ↑
- Cognitive tests ↑
- Attention ↑
- Cognitive flexibility ↑
- P3 amplitude ↑ (task that require great amount of cognitive control)
- Flexibility of brain functions

→ Positive effect of physical activity on cognition and Brain functions



Hillman et al, 2014

Cycling desks



RESEARCH ARTICLE

Cycling on a Bike Desk Positively Influences Cognitive Performance

Tina Torbeys¹, Bas de Geus^{2*}, Stephan Bailey³, Kevin De Pauw³, Liesbet Decroos¹, Jean-Pierre Chastin¹, Vian Meeusen¹, Pieter Verheyen¹
 1 Human Physiology Research Group, Vrije Universiteit Brussel, Brussels, Belgium, 2 Department of Physical Therapy Education, Elon University, Elon, United States of America, 3 School of Public Health, Tropical Medicine and Rehabilitation Sciences, James Cook University, Queensland, Australia



Cycling desk : typing, cognitive performance, brain activity

- 23 office workers
- 'normal' typing
- Typing @ cycling desk
- Typing performance =
- Word recognition =
- Reaction time ↑
- Selective attention ↑
- Sustained attention ↑

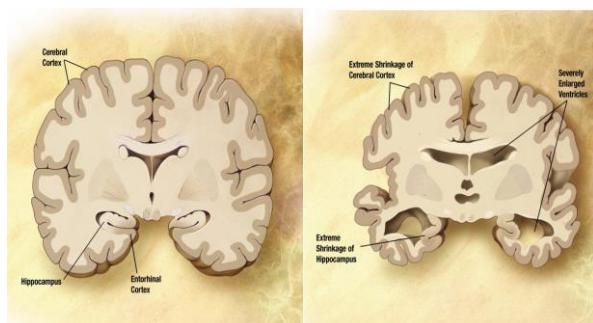
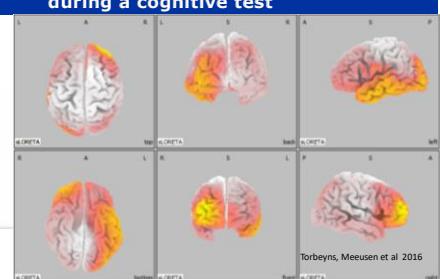


Torbeys, Meeusen et al 2016

Increased brain activation between cycling & sitting during a cognitive test



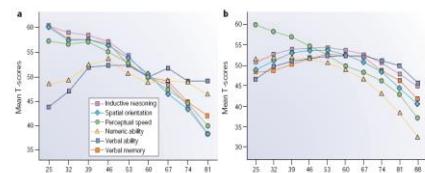
Torbeys, Meeusen et al 2016



Cognition declines with age



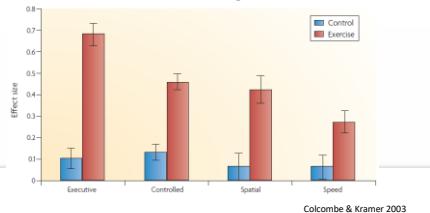
Cross sectional & Longitudinal evidence



(Hedden & Gabrieli, 2004)

Exercise effect on Cognition in Older adults

Meta-analysis : effect sizes demonstrate positive influence of exercise on cognition



Exercise, Brain Volume, Cognition

- 1 yr physical activity or stretching
- 2 x 60 subjects
- Mean age 65.6 – 67.5yr
- 40 min of walking 2-3/Wk or stretching

→ ENDURANCE EXERCISE

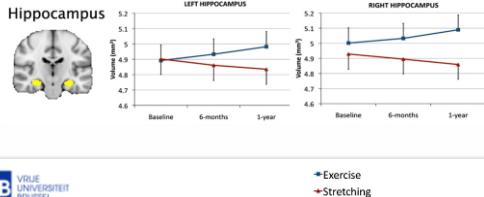


Erickson et al 2011



1 yr aerobic exercise (RCT)

Hippocampus remains plastic in late adulthood



Strength Training & Cognition

Randomised controlled trials

- Age : 65-75yr
- Training : 24 WK (Cochrane 2007) ~ 15% (1h-Am)
- # Tr/wk: 1 – 3x/wk
- Cognitive tests (pre-post & c)

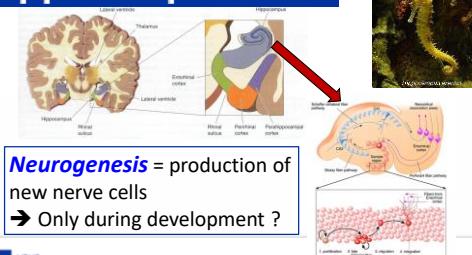
• sign ↑ scores on



Casillas et al 2007; Liu-Ambrose et al 2010, 2012; Davis et al 2010



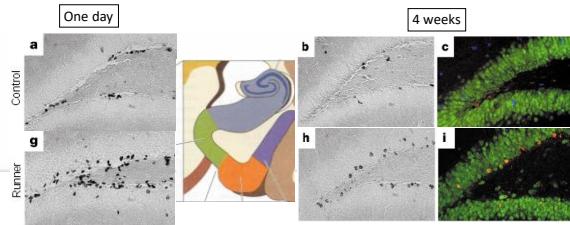
Hippocampus



Voluntary running

(Van Praag et al *Nature neurosci* 1999)

Enhances the survival of 'newborn' neurons = **cell proliferation**
Or in **neurogenesis** (4 weeks old cells)



Mechanisms ?

Cerebral circulation
Neuronal efficiency
Glucose regulation
...



Neurotrophic factors



Brain derived neurotrophic factor (BDNF)

Is the most abundant **neurotrophin** in the brain
→**growth factor** within the brain
Serves as a **neurotransmitter modulator**
Participates in use-dependent **plasticity** mechanisms
It **supports the survival** of many neuronal subtypes
BDNF expression is diminished in Alzheimer's disease



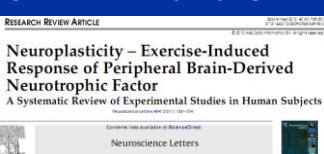
To summarise

Brain plasticity exists
Enriched environment is important
Exercise is a 'common' feature in enrichment

Also 'Learning' improves

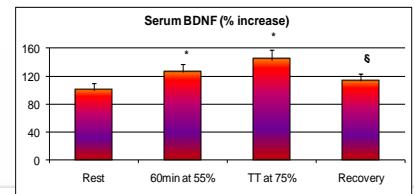


What about BDNF in Humans ?



BDNF increases in peripheral blood due to exercise

60 min @ 55% Wattmax + TT @ 75% Wattmax



Goeksema et al 2008, 2011 – Van Cutsem et al 2015 – Tonoli et al 2015

Acute exercise & BDNF

- Depends on the exercise intensity & duration
- Exercise increases peripheral BDNF
- Also in patient populations
- Dose response to intensity



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Serum BDNF (ng/ml) before (PRE) and following (POST) strength training



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No effect of a single strength session
&
No effect of a 10 week training program

BDNF & Strength training



*Bar Ivert Physiol (2010) 110:285–291
DOI 10.1007/s10238-010-9452-5
ORIGINAL ARTICLE
Strength training does not influence serum brain-derived neurotrophic factor
Masilke Gokkint · Kevin De Pauw · Bart Roelands ·
Rene Nijhuis · Ivan Baatmans · Tony Meeus ·
Boudewijn Meeusen*

RCT : Training program during 10 weeks, with a frequency of 3 training sessions per week

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Gokkint, et al 2010

Strength Training & BDNF

Randomised controls

- N = 2x20 subjects
- Age : 62-72yr
- Training : 12 wk Stre
- 3x/Wk
- Strength ↑

Strength Training & Cognition

- Randomised control trials
- Age : 65-75yr - n=100
- Training : 24 wk (Goto et al 2007) – 1x/wk
- 3 Tr/wk : 1 – 2x/wk
- Cognitive tests (pre-post & d)
- sign T scores on

→ Positive effect of strength training on cognition in elderly



Caselli et al 2007, Goto Akeno et al 2010, 2011, Deix et al 2010

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Forti, Meeusen et al 2014

Control PST

Exercise, cognition & the Brain, ...

Mechanisms ?



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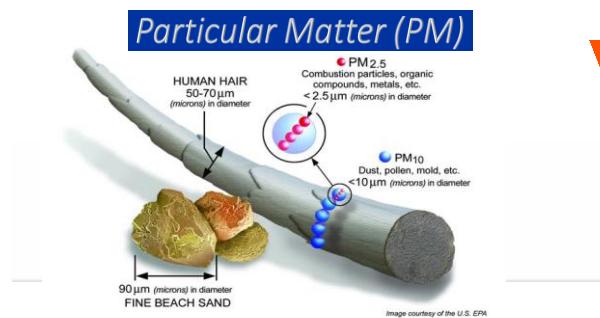
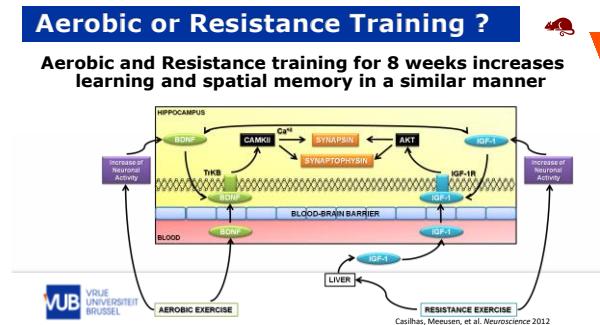
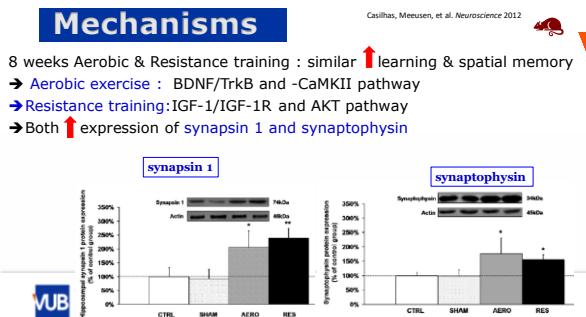
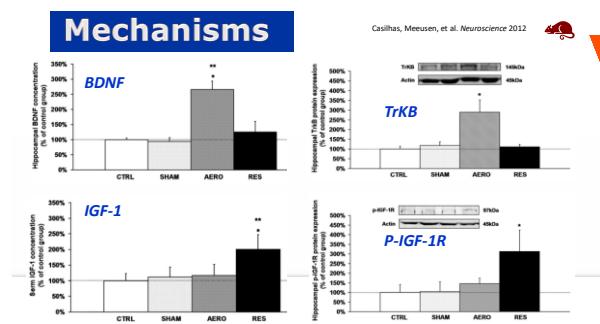
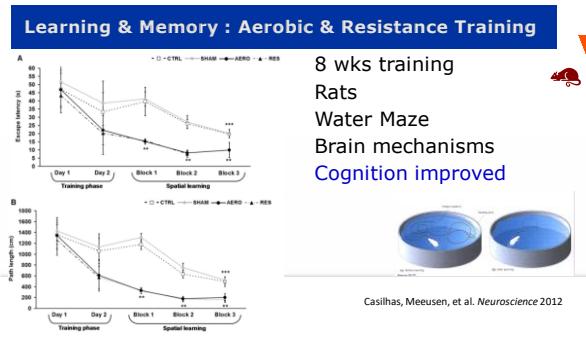
Endurance – Resistance

8 wks training



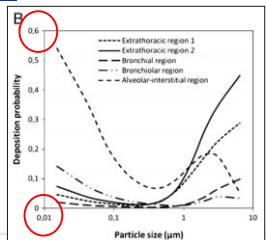
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Casillas, Meeusen, et al. Neuroscience 2012



Inhaled particles

The smaller the particles → the deeper the penetration



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Oravaisjärvi, et al. 2011, Daigle et al 2003; Int Panis, Meeusen et al 2010

Cognition & Pollution

Longitudinal evidence

4009

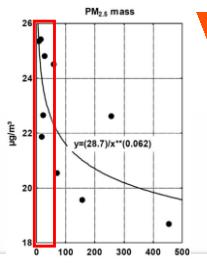
Age: 68-79 yrs

More than 20yrs same residential address

Distance to road : 50-100m

Brain inflammation and cognitive decline

Chronic exposure to traffic-related PM
→ development of MCI

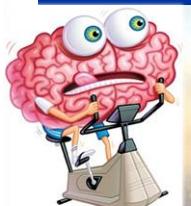


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Ranft et al 2009

Distance from busy road (m)

Exercise, Pollution & the Brain



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Antwerp 'motorway'

10-lane motorway

Ca 260,000 cars (50,000 trucks) per day

Cycle path between 10 & 100 m from the road

→ cycle 20 min @ self chosen intensity

→ measurement of Hf, (intensity)

Cycling parameters	Antwerp Ring	Clean room
Duration of cycling, Min	20.7 (1.7)	20.2 (1.9)
Heart rate, beats/Min	131 (14.8)	131 (14.6)
Ventilation, L/Min	55.4 (12.7)	55.2 (13.1)

Bos et al 2011; Jacobs et al 2010

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Exercise, Pollution & BDNF

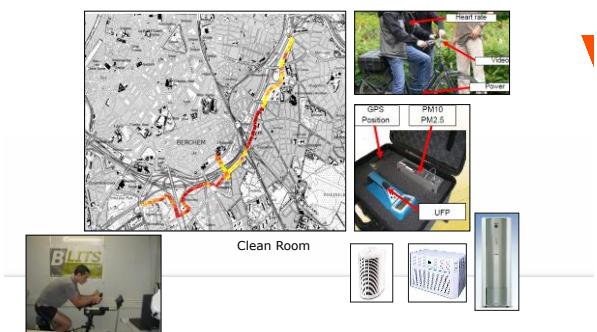


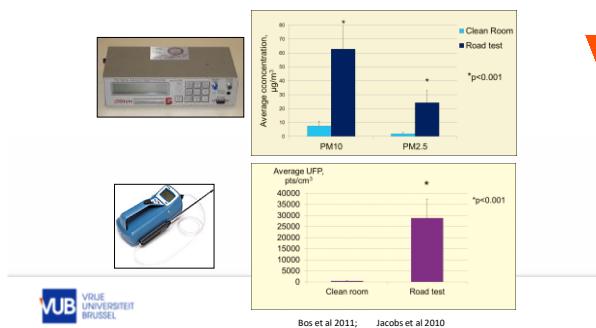
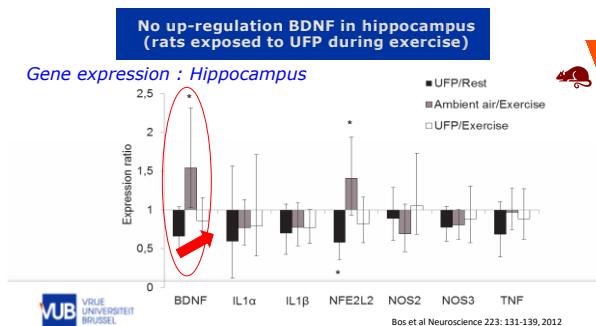
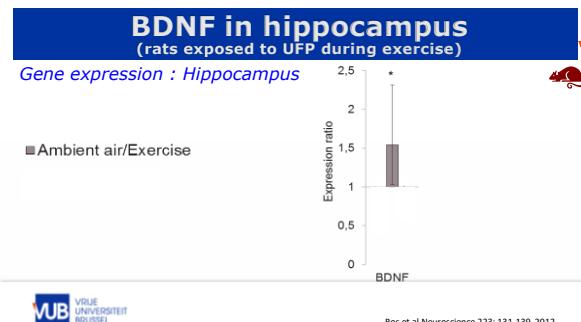
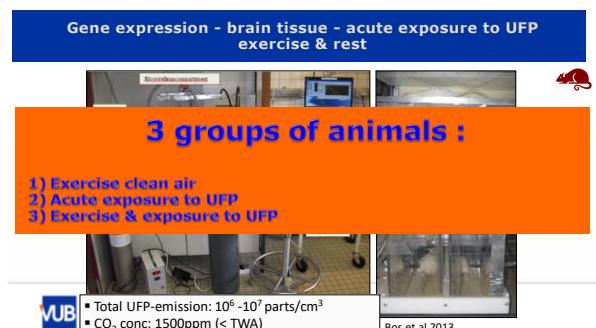
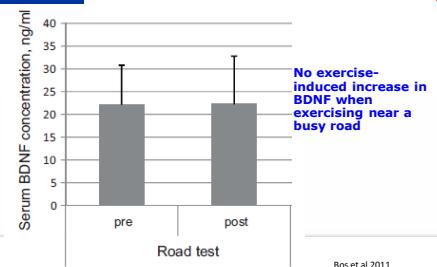
No exercise-induced increase in serum BDNF after cycling near a major traffic road

I. Bos ^{a,b}, L. Jacobs ^a, T.S. Nawrot ^{c,d}, B. de Geus ^b, R. Torfs ^b, L. Int Panis ^{a,d}, B. Degraeuwe ^b, R. Meeusen ^{a,*}

ANTWERP RING ↔ CLEAN ROOM

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**Serum BDNF**

Start - to - Run campaign

Inactive participants
12 weeks **start-2-Run (S2R)**, 3x/wk
UFP contrast



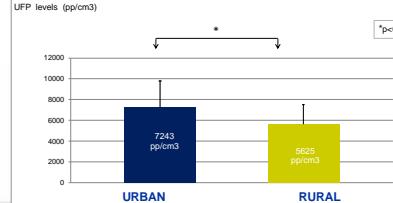
Urban area : Brussels (n=21)
Rural area : Mol (n=13)
PTRAK measurements each training session



Bos et al MSSE, 2013

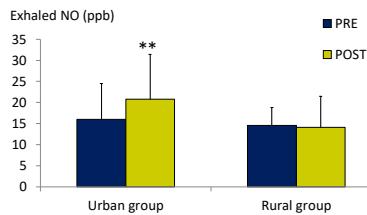
Results: UFP levels

Average UFP levels during the program in Brussels & Mol.



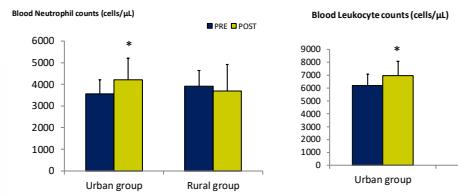
Bos et al MSSE, 2013

Respiratory inflammation



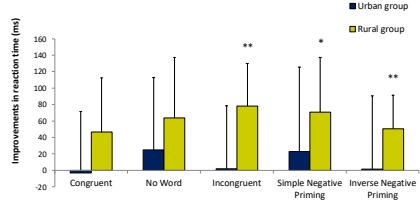
Bos et al MSSE, 2013

Systemic inflammation



Bos et al MSSE, 2013

Stroop Color Word Test



Bos et al MSSE, 2013

Conclusions

Exercise is good for brain Health



Bewegen als werk → stimuleert neurogenese en cognitie
Bewegen op het werk → positief effect en verbeterde
 brein activiteit

Bewegen naar het werk → opletten met pollutie !



www.blits.org

 @RomainMeeusen

