Is bewegen goed voor het Brein ?

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Inhoud

Bewegen – cognitie
Mechanismen – neurogenese
Welke soort beweging ?
Bewegen – cognitie en pollutie

Health benefits of exercise

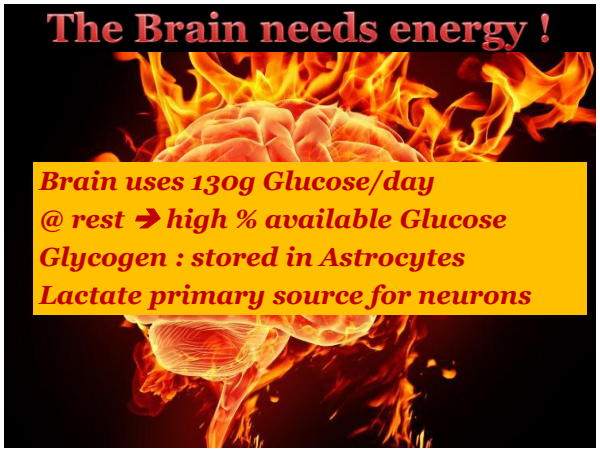
- Obesity
- Diabetes
- Cardiovascular diseases
- Hypertension
- COPD
- Osteoarthritis
- Osteoporosis
- ....

- Cognition
- Parkinsons disease
- Alzheimers disease
- Stroke
- Depression
- Spinal cord injury
- ...

Brein

Ca 1300 gram
1.10^{11} cellen (honderd miljard)
Elk 5000 à 10000 verbindingen
➔1.10^{15} synapsen
150.000km zenuwvezels

The Brain needs energy !



Brain uses 130g Glucose/day
@ rest ➔ high % available Glucose
Glycogen : stored in Astrocytes
Lactate primary source for neurons

Neurotransmitters

- Serotonin (5-HT)
- Dopamine
- Noradrenaline
- Acetylcholine
- GABA
- Glutamate
- …

Cognitie

De onderliggende operaties die door het centrale zenuwstelsel worden gebruikt om informatie te verwerken.

- Geheugen
- Aandacht
- Perceptie
- Problem solving
- Reactie tijd
- Snelheid uitvoering van handelingen en bewegingen

Bewegen & school prestaties

Aerobic Fitness

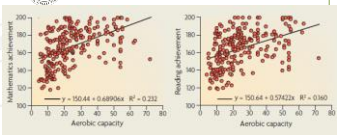
➔Positieve relatie met schoolprestaties

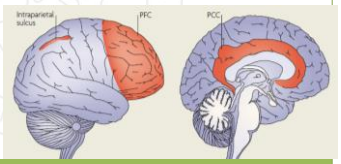
BMI ➔ Negatieve relatie

Relevante neurale netwerken

➔Prefrontal Cortex

➔Parietal/Posterior Cingulate Cortex

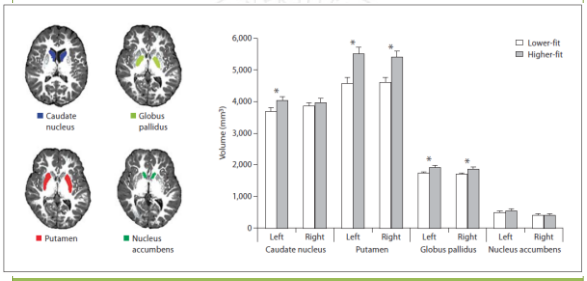




Hillman et al 2008

Basal ganglia volume pre-adolescente kinderen

Duidelijke associatie met *aerobic fitness*



Chaddock et al 2010

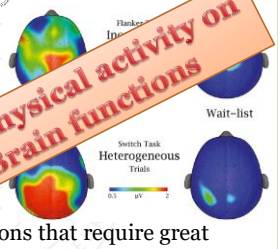
Physical Activity intervention

- 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 ↑



→Positive effect of physical activity on cognition and Brain functions

- …ior conditions that require great
- …executive control
- …bility of Brain Functions

Hillman et al, 2014

Cycling desks

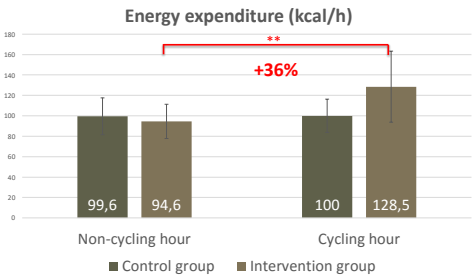
Sports Med (2014) 44:1261–1273
DOI 10.1007/s40279-014-0202-x

SYSTEMATIC REVIEW

Active Workstations to Fight Sedentary Behaviour

Tine Torbeyns · Stephen Bailey · Inge Bos · Romain Meeusen

Results: EE



** p ≤ 0.001

Vrije Universiteit Brussel

Cycling desk : typing, cognitive performance, brain activity

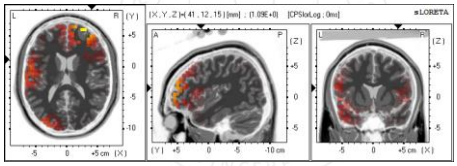
- **23 office workers**
- 'normal' typing
- Typing @ cycling desk

- Typing performance =
- Word recognition =
- Reaction time ↑
- Selective attention ↑
- Sustained attention ↑

Torbeyns, Meeusen et al submitted

Brain activity

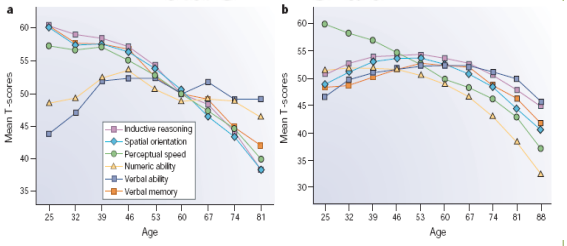
- Difference in brain activity between ‘sitting’ & ‘cycling’ desk
- More brain activity – more active Brains



Torbeyns, Meeusen et al submitted

Cognitieve prestaties dalen met de leeftijd

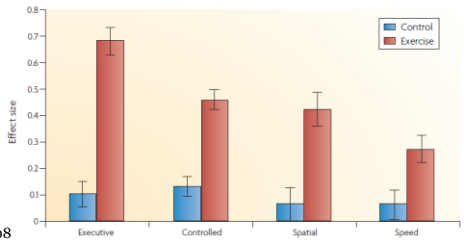
- Cross sectional Longitudinal



(Hedden & Gabrieli, 2004)

Exercise effect : Cognitie ouderen

Meta-analysis : positieve invloed van inspanning op cognition



Hillman et al 2008

Exercise, Brain Volume, Cognition

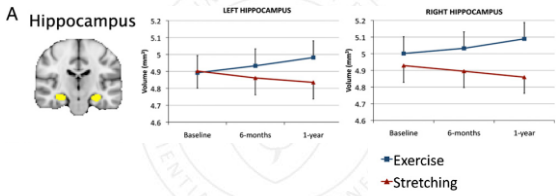
- 1 yr physical activity or stretching
- 2 x 60 ppn
- Gemidd lftd : 65.6 – 67.5yr
- 40 min wandelen; of stretching
- 2-3/Wk

➔ ***‘duur’-inspanning***

Erickson et al 2011

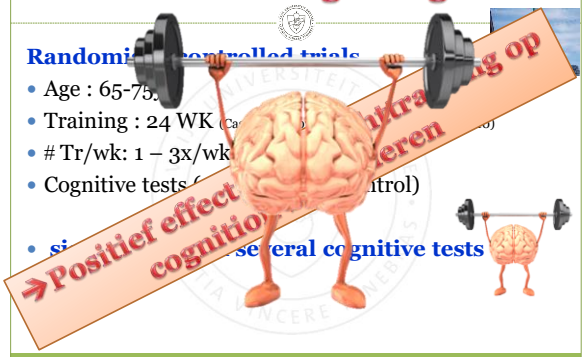
1 yr aerobic exercise (RCT)

Hippocampus blijft 'plastisch' op latere lftd



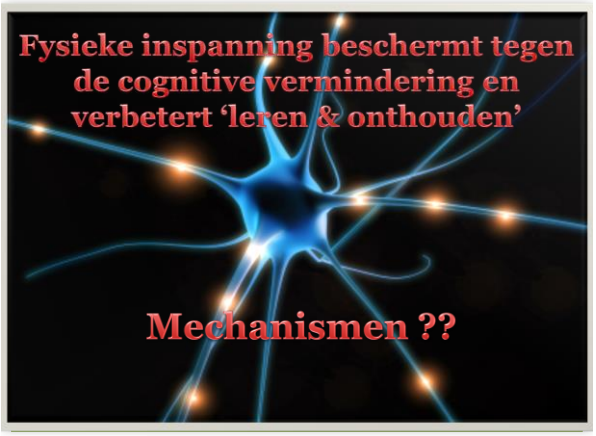
Erickson et al 2011

Kracht Training & Cognitie



- **Randomi[illegible]ontrolled trials**
- Age : 65-75[illegible]
- Training : 24 WK (Ca[illegible])
- # Tr/wk: 1 – 3x/wk[illegible]
- Cognitive tests [illegible]trol)
- **si[illegible]se[illegible]veral cognitive tests**

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



Mechanismen ?

Cerebrale circulatie
Neuronale efficientie
Glucose regulatie
…

Neurotrophic factors

Exercise & Neurogenesis

Aanmaak van nieuwe hersencellen

➔ **is dit een Dogma ?**

Hersencellen sterven af …

en worden

Neurogene

BESTAA

➔Enkel tij

Ramon y C

fasen in

➔ en die e

Vanaf 196

Eind vorig

Elke dag worden er duizenden nieuwe cellen toegevoegd aan het brein van zoogdieren

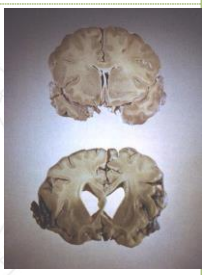
➔ procentueel weinig in vergelijking tot het totaal aantal hersencellen, maar dit geeft aan dat er een duidelijk structurele verandering mogelijk is

Vermindering neuronen

acute & chronische stress; veroudering

➔Glucocorticoiden, morfine, heroine, alcohol, …

➔Pathologische omstandigheden : Alzheimers Disease, Parkinson's Disease, …



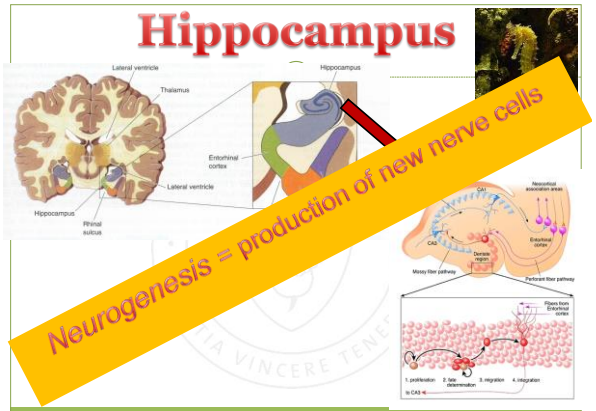
Nieuwe hersencellen

Kunnen enkele dagen overleven, maar sommige blijven een leven lang bestaan

➔ De hersencellen die op volwassen leeftijd worden aangemaakt hebben voornamelijk hun belang bij leerprocessen en geheugen.

Hippocampus

Hippocampus



Brain Derived Neurotrophic Factor (*BDNF*)

Is de meest wijd verspreide neurotrophine in de hersenen

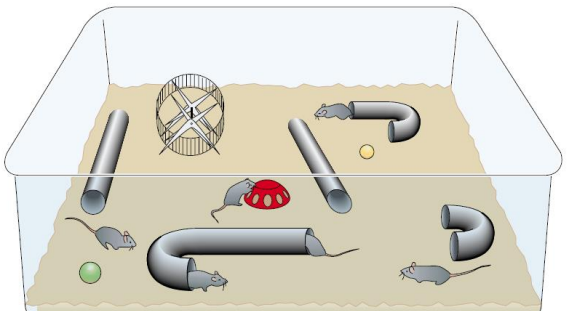
Het bevordert de groei en het onderhoud van verschillende neuronale systemen

Is betrokken bij leerprocessen

BDNF expressie is verminderd bij patienten met Alzheimer's disease

Enriched environment = verrijkte omgeving

speeltjes, loopwieltjes, grotere kooien, ...

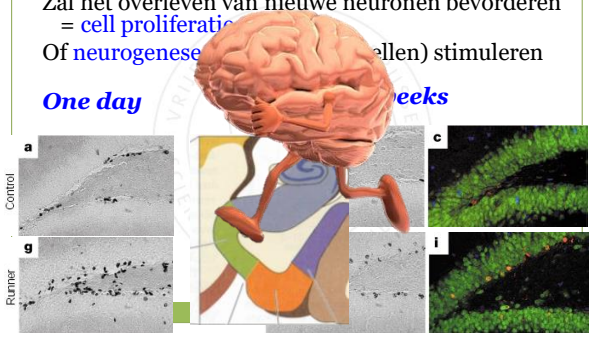


Voluntary running

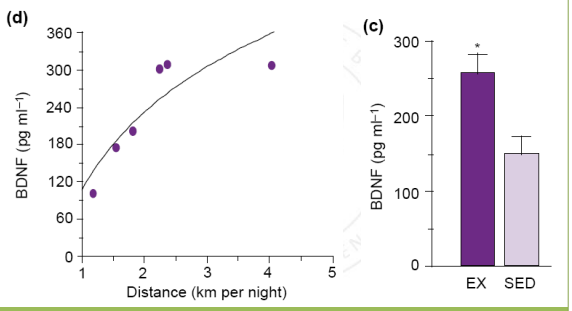
(Van Praag et al Nat neurosci 1999)

Zal het overleven van nieuwe neuronen bevorderen
= cell proliferati
Of neurogenese ellen) stimuleren

One day ***eeks***



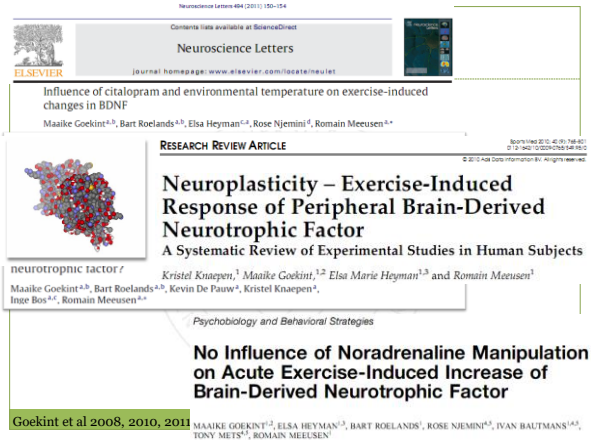
BDNF expression correlates with the distance run per night



(Cotman & Berchtold TINS 2002)

Wat bij de mens ?

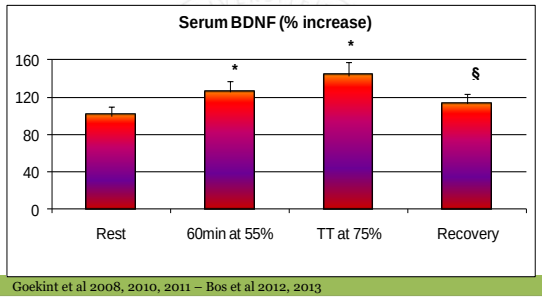
- Verschillende studies hebben in serum verhoogde BDNF concentraties gevonden
- Is dit een indicator van wat er in de hersenen gebeurt ?



Goekint et al 2008, 2010, 2011

BDNF increases in peripheral blood due to exercise

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



Goekint et al 2008, 2010, 2011 – Bos et al 2012, 2013

BDNF & Strength training

Eur J Appl Physiol (2010) 110:285–293
DOI 10.1007/s00421-010-1461-3

ORIGINAL ARTICLE

Strength training does not influence serum brain-derived neurotrophic factor

Maaike Goekint · Kevin De Pauw · Bart Roelands · Rose Njemini · Ivan Bautmans · Tony Mets · Romain Meeusen

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

Goekint, et al 2010

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

Total training period (10wks)	Single … ing

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

Goekint, et al 2010

Strength Training & BDNF

Randomised controlled trial

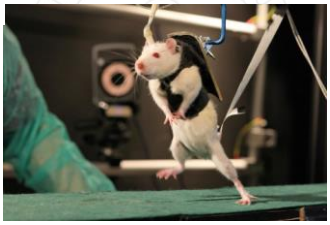
- N = 2x20 subjects
- Age : 62-72yr
- Training : 12 wk Strength training
- 3x/Wk
- Strength ↑

- BDNF

Forti, Meeusen et al 2014

Exercise, cognition & the Brain, …

Mechanisms ?



Cognition & Strength training

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Strength training does not influence serum brain-derived neurotrophic factor

Maaike Goekint · Kevin De Pauw · Bart Roelands · Rose Njemini · Ivan Bautmans · Tony Mets ·

Training study in young & old adults → no increase in peripheral BDNF
But
Improvement in cognition

?? Mechanisms → animal study

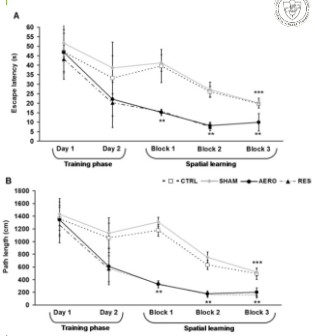
Goekint, et al 2010, Forti et al 2014, Cassilhas et al 2007; Liu-Ambrose et al 2010, 2012; Davis et al 2010

Endurance – Resistance

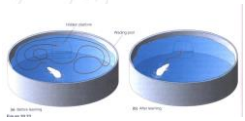
8 wks training

Casilhas, Meeusen, et al. *Neuroscience* 2012

Learning & Memory : Aerobic & Resistance Training

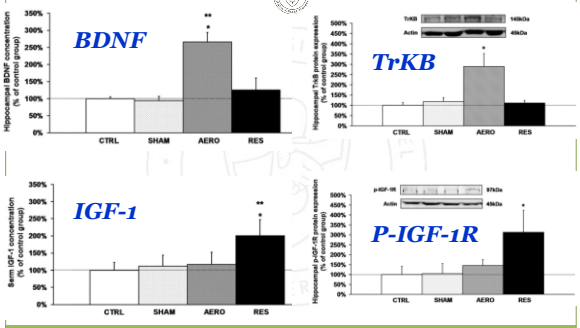


8 wks training
Rats
Water Maze
Brain mechanisms
Cognition improved



Casilhas, Meeusen, et al. *Neuroscience* 2012

Mechanisms

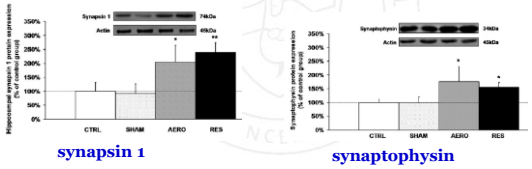


Casilhas, Meeusen, et al. *Neuroscience* 2012

Mechanisms

Aerobic and Resistance training for 8 weeks increases learning and spatial memory in a similar manner.

- Aerobic exercise modulates BDNF/TrkB and -CaMKII
- Resistance training acts on the CNS via IGF-1/IGF-1R and AKT pathway
- Both induced the expression of synapsin 1 and synaptophysin, which might contribute to improved spatial learning and memory.



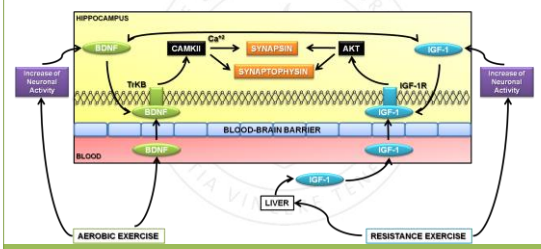
synapsin 1 **synaptophysin**

Casilhas, Meeusen, et al. *Neuroscience* 2012

Aerobic or Resistance Training ?

Aerobic and Resistance training for 8 weeks

➔ ***Synaptic Plasticity***

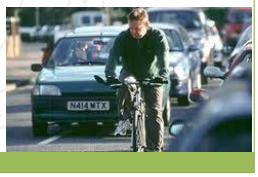


Casilhas, Meeusen, et al. *Neuroscience* 2012

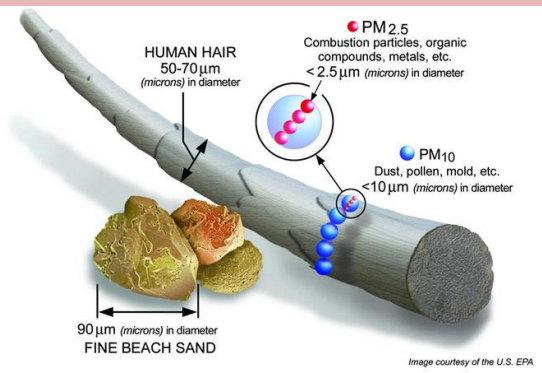
Dus, …

- Inspanning is goed voor het Brein !
- Inspanning bevordert de cognitie zowel op jonge als op oudere leeftijd
- Duidelijk bewijs dat men nieuwe neuronen aanmaakt tijdens inspanning
- BDNF speelt hierbij een belangrijke rol
- Maar er is een limiet
- … is dit altijd het geval ?

Exercise & Pollution



Particular Matter (PM)

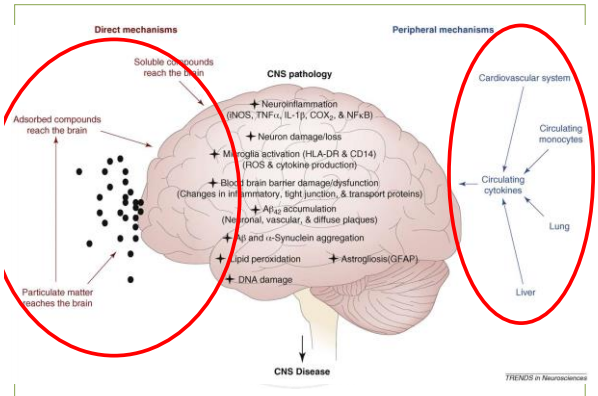


Pollution

Long-term exposure to traffic-related air pollution :

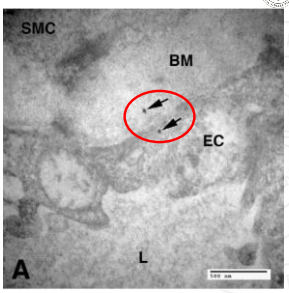
- Cardiovascular & pulmonary disease
- **M**ild **C**ognitive **I**mpairment in Elderly (Ranft et al 2009) ➔ distance < 50m from busy traffic road
- PM10 predicts cognitive function (Chen 2009)

Pollution & the Brain



Block & Calderon-Garciduenas 2009

Children Mexico City



Olfactory bulb arteriole

Small particles

Calderon-Garciduenas et al 2010

Ultrafine Particle Deposition in Humans During Rest and Exercise

Atmospheric Environment 44 (2010) 2263–2270

Contents lists available at ScienceDirect

Atmospheric Environment

journal homepage: www.elsevier.com/locate/atmosenv

Exposure to particulate matter in traffic: A comparison of cyclists and car passengers

Luc Int Panis [a,b,*], Bas de Geus [c], Grégory Vandenbulcke [d], Hanny Willems [a], Bart Degraeuwe [a], Nico Bleux [a], Vinit Mishra [a], Isabelle Thomas [d], Romain Meeusen [c]

Daigle et al 2003; Int Panis, Meeusen et al 2010

Exercise, Pollution & BDNF


Neuroscience Letters

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

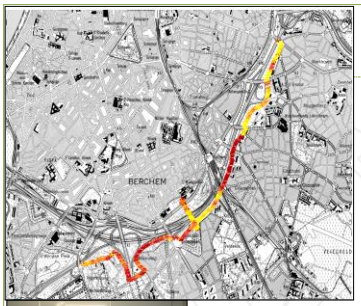

RESEARCH Open Access

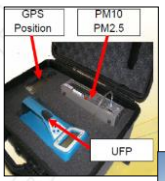
Subclinical responses in healthy cyclists briefly exposed to traffic-related air pollution: an intervention study

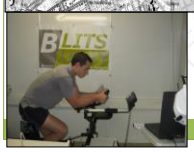
ANTWERP RING ↔ CLEAN ROOM

Antwerp 'motorway'

Bos et al 2011; Jacobs et al 2010

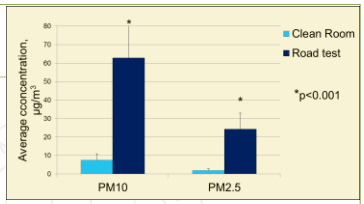


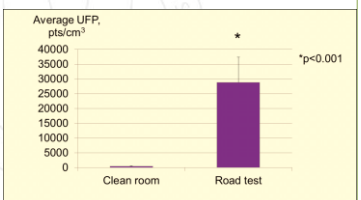




Clean Room

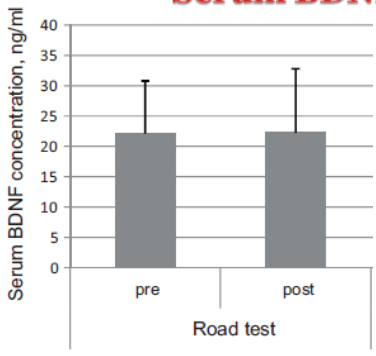
Bos et al 2011; Jacobs et al 2010





Bos et al 2011; Jacobs et al 2010

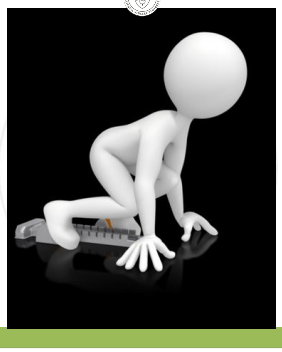
Serum BDNF



No exercise-induced increase in BDNF when exercising near a busy road

Bos et al 2011

Start - to - Run campaign



Start - to - Run campaign

Inactive participants

Subclinical Effects of Aerobic Training in Urban Environment

INGE BOS[1,2], PATRICK DE BOEVER[1,3], JEF VANPARIJS[2], NATHALIE PATTYN[2,4], LUC INT PANIS[1,5], and ROMAIN MEEUSEN[2]

[1]Environmental Risk and Health, Flemish Institute for Technological Research (VITO), Mol, BELGIUM; [2]Human Physiology and Sports Medicine, Vrije Universiteit Brussel, Brussels, BELGIUM; [3]Centre for Environmental Sciences (CMK), Hasselt University, Diepenbeek, BELGIUM; [4]Vital Signs and Performance Monitoring (VIPER) Research Unit, Royal Military Academy, Brussels, BELGIUM; and [5]Transportation Research Institute (IMOB), Hasselt University, Diepenbeek, BELGIUM

PTRAK [illegible] *Med. Sci. Sports Exerc.*, Vol. 45, No. 3, pp. 439–447, 2013.

Bos et al, 2013

Biological outcome measures

Fitness level: cooper test

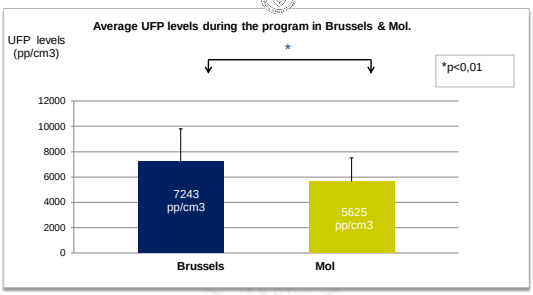
Cognitive performances

Blood leukocyte counts
Serum BDNF level
whole genome gene expression

eNO measurements

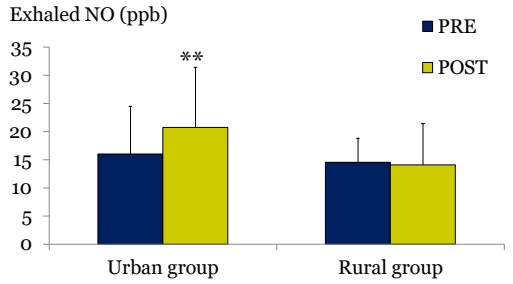
Bos et al, 2013

Results: UFP levels



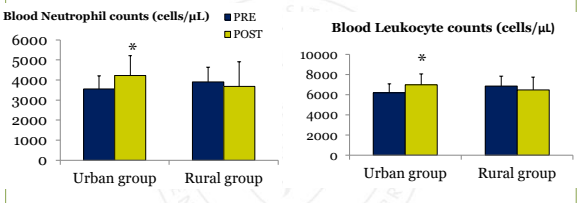
Bos et al, 2013

Respiratory inflammation



Bos et al, 2013

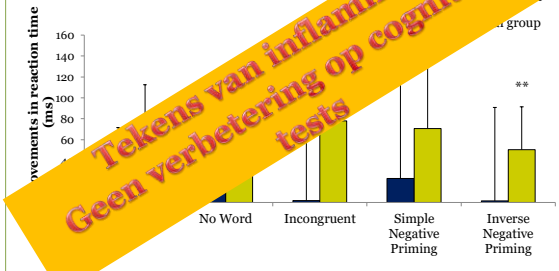
Systemic inflammation



Bos et al, 2013

Stroop Color Word Test

Tekens van inflammatie
Geen verbetering op cognitieve tests



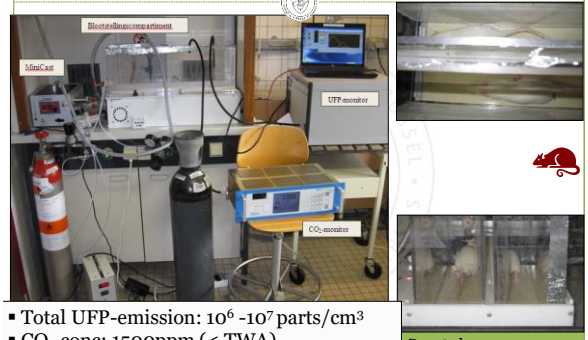
Bos et al, 2013

Dus,

- Inspanning in een vervuilde omgeving onderdrukt de perifere expressie van BDNF
- Training (10wkn) :
- Verbetert de conditie ☺
- Systemische en Respiratoire inflammatie (pollutie)
- Geen verbetering op cognitieve tests
- ➔ Mechanismen ??

Mechanisms

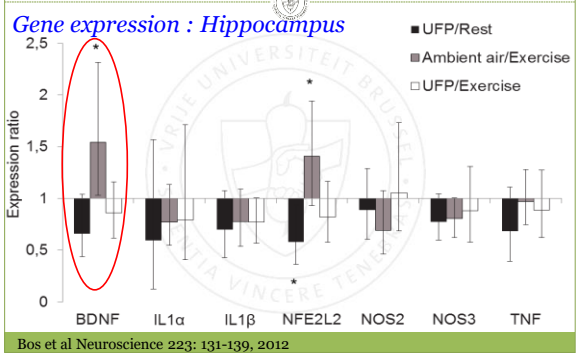
Gene expression changes in rat brain tissue after acute exposure to ultrafine particles during exercise and rest



- Total UFP-emission: 10^6 -10^7 parts/cm^3
- CO_2 conc: 1500ppm (< TWA)

Bos et al 2012

No up-regulation BDNF in hippocampus rats exposed to UFP during exercise



Bos et al Neuroscience 223: 131-139, 2012

Muizen in de Craeybecks Tunnel

Inhalation Toxicology, 2012; 24(10): 676–686
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DOI: 10.3109/08958378.2012.714004

informa healthcare

RESEARCH ARTICLE

Changed gene expression in brains of mice exposed to traffic in a highway tunnel

Inge Bos[1,2], Patrick De Boever[1,3], Jan Emmerechts[4,5], Jurgen Buekers[1], Jeroen Vanoirbeek[5], Romain Meeusen[2], Martine Van Poppel[1], Benoit Nemery[5], Tim Nawrot[1,5], and Luc Int Panis[1,6]

Bos et al MSSE, 2012

Results

- Air quality: Tunnel vs. Traffic control Centre
  - The average concentration of measured pollutants

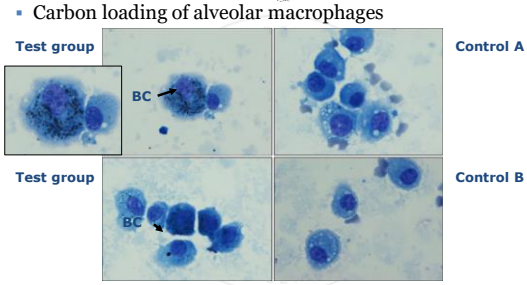
Pollutant	Tunnel	Traffic Control centre	Factorial difference
PM2.5	55.1 µg/m³	29.4 µg/m³ *1	±2
EC	13.9 µg/m³	2.04 µg/m³ *2	±7
OC	23.1 µg/m³		
UFP	150 000 particles/cm³	6 000 particles/cm³	±25

*1 Monitoring station in City of Antwerp
*2 Reported in Flanders (Vercauteren, 2011)

Bos et al MSSE, 2012

Results

- Carbon loading of alveolar macrophages

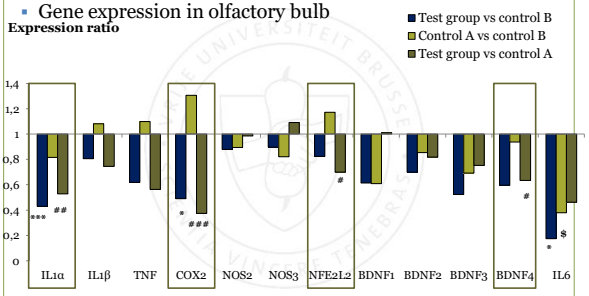


- **Physiological signs of inflammation**

Bos et al MSSE, 2012

Results

- Gene expression in olfactory bulb



Bos et al MSSE, 2012

Besluit (1)

Cognitie en andere hersenfuncties : dalen met de toenemende leeftijd

Regelmatige beweging **remt** deze daling

Zelfs het starten van oefenen op 'latere' leeftijd bevordert de cognitie

Brain Derived Neurotrophic Factor (BDNF)

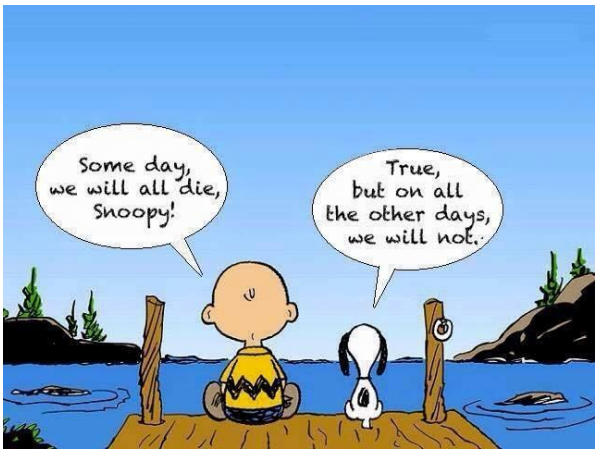
- Is een groeifactor voor hersencellen & neuronale systemen
- Toename in BDNF loopt gelijk met een aantal functionele en structurele verandering in de hersenen

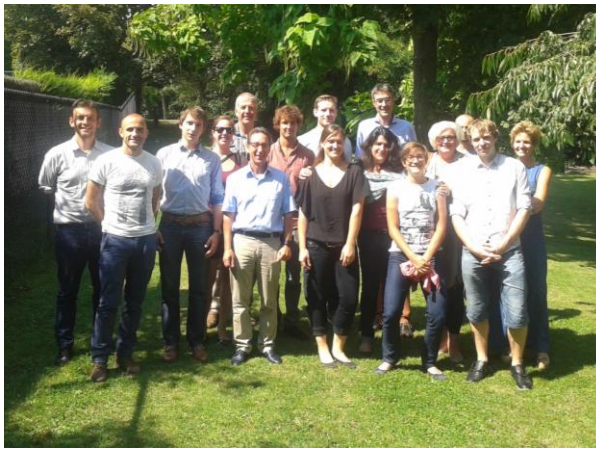
Besluit (2)

Inspanning en '*enriched environment*' hebben aangetoond dat :

- ➔er anatomische veranderingen optreden in de hersenen
- ➔het aanleren van motorische processen (bv revalidatie) bevorderd wordt

Sporten in een vervuilde omgeving mogelijk negatieve gevolgen heeft






Thank You