Cycling to work

Google: Commuter Cycling and Health

Benefits of Cycling
- Reduce Stress
- Reduce risk of diabetes and high blood pressure
- Increase muscle tones
- Strong heart and big lungs
- Bones of steel
- Chiseled legs
- Faster than walking
- See the world through different eyes
- No noise pollution
- Runs on fat not fuel
- Reduce road kills and save animals
- Bye bye spare tires
- Money in your pocket not in fuel tank

raworbeauty.com
Introduction: Epidemiological studies

**Conclusions:** Leisure time physical activity was inversely associated with all-cause mortality in both men and women in all age groups. Benefit was found from moderate leisure time physical activity, with further benefit from sports activity and bicycling as transportation.

*Arch Intern Med. 2000;160(2):1621-1628*

**Conclusions:** Active commuting that incorporates walking and cycling was associated with an overall 11% reduction in cardiovascular risk, which was more robust among women. Future studies should investigate the reasons for possible gender effects and also examine the importance of commuting activity intensity.

*Arch Intern Med. 2009;169(13):1216-1223*

Introduction: Intervention studies

Physiological effects of walking and cycling to work:


**Conclusion:** These findings indicate that low-intensity walking and cycling to and from work improved cardiorespiratory and metabolic fitness.

Effect of commuter cycling on physical performance of male and female employees

ENZIO J. M. HENDRIKSEN, DOB ZUDEK, YLDI DANN C. O. KENFER, and P. DICK BREDNER.

Department of Physiology, Faculty of Medicine, VU University, Amsterdam, THE NETHERLANDS and Institute for Research in Entrepreneur Medicine (IREM), Faculty of Medicine, VU University, Amsterdam, THE NETHERLANDS.

The relationship between cycling and physical performance was analyzed in 104 healthy employees. The study was designed to investigate the effect of commuting cycling on physical performance. The results showed that commuting cycling resulted in a significant improvement in physical performance. The study also demonstrated a dose-response relationship between cycling frequency and physical performance. *Key Words: Maximal External Power, Maximal Oxygen Uptake, Exercise Testing, Cycle Ergometry, Exercise*
Introduction: Intervention studies

Concluding we can state that, based on the results of this study, cycling to work has the potential to increase physical performance in an untrained study population. The maximal external power and peak oxygen uptake significantly changed over time when the IG and CG were compared. Weak, but significant correlations were found between the peak oxygen uptake and total volume in the first period.

Introduction: Systematic Review – Health Benefits

We conclude that this lifestyle intervention study, where subjects had to cycle to and from work for 1 year, had a positive influence on CHD risk factors and was likely to improve the health-related QOL of previously untrained healthy adults.
So ???

Commuter Cycling positive on Health ??
Are cyclists exposed to higher risks due to **air pollution** and **accidents**?

**HEALTH**

Back-ground air pollution – Long-term

Cardiovascular Mortality and Long-Term Exposure to Particulate Air Pollution
Epidemiological Evidence of General Pathophysiological Pathways of Disease

C. Arden Pope III, PhD; Richard T. Burnett, PhD; George D. Thurston, ScD; Michael J. Thun, MD; Eugenia E. Calle, PhD; Daniel Krewski, PhD; John J. Godleski, MD

**Conclusion**: Fine particulate air pollution is a risk factor for cause-specific cardiovascular disease mortality via mechanisms that likely include pulmonary and systemic inflammation, accelerated atherosclerosis, and altered cardiac autonomic function. Although smoking is a much larger risk factor for cardiovascular disease mortality, exposure to fine PM imposes additional effects that seem to be at least additive to if not synergistic with smoking. (*Circulation*, 2004; 109:71-77.)
Long-Term Effects of Traffic-Related Air Pollution on Mortality in a Dutch Cohort (NLCS-AIR Study)

Rob Beelen,1 Gerard Hoek,1 Pieter A. van den Brandt,2 R. Alexandra Goldbohm,3 Paul Fischer,4 Leo J. Schouten,2 Michael Jerrett,2 Edward Hughes,6 Ben Armstrong,1 and Bert Brunekreef1,8

CONCLUSIONS: Traffic-related air pollution and several traffic exposure variables were associated with mortality in the full cohort. Relative risks were generally small. Associations between natural-cause and respiratory mortality were statistically significant for NO2 and BS. These results add to the evidence that long-term exposure to ambient air pollution is associated with increased mortality.

Micro-environment traffic air pollution – Short-term

Differences in cyclists and car drivers exposure to air pollution from traffic in the city of Copenhagen:

Jens Rack6, Jens Folk5, Per Homann Jaspers1

5. Conclusion

On the basis of this study, we can conclude that cyclists in the city of Copenhagen are exposed to lower concentrations of traffic-related pollutants than car drivers. Furthermore, we conclude that car drivers experience 3-4 times higher BTEX concentrations and approximately two times higher exposure of particles than bikers. The study also indicates that the air children breathe may be better on the back of a bicycle than inside a car.
What do we forget?

Physical effort (VE) of cycling >> car driving

⇒ Inhaled # particles: cyclist >> driver ??

Project: SHAPES

Literature: ventilation – exposure

<table>
<thead>
<tr>
<th>Study</th>
<th>Measurement - Estimation</th>
<th>Bicycle/car ventilation ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Vrijkotte (unpublished))</td>
<td></td>
<td></td>
</tr>
<tr>
<td>O’Donoghue (2007)</td>
<td>Estimation - HR</td>
<td>2.6</td>
</tr>
<tr>
<td>Zuurbier (2009)</td>
<td>Estimation - HR</td>
<td>2.1</td>
</tr>
</tbody>
</table>
Micro-environment traffic air pollution – Short-term

![Graph showing concentration over time](attachment:image.png)

Materials & Methods

- N = 55 healthy adults
- Field tests: Cycling + Car passenger (cross-over experiment)
  - Breath-by-breath ergospirometry (MetaMax 3B) → Minute Ventilation
  - Particle Number Conc (UFP) + Particulate Matter (PM10, PM2.5)

→ Exposure = ventilation per distance x concentration x distance
Materials & Methods

- 3 ≠ locations:
  - flat – hilly
  - polluted – non-polluted
Results – Air pollution

**UFP (PNC/cm³)**

- Brussels
- LLN
- Mol

**PM10 (µg/m³)**

- Brussels
- LLN
- Mol

Values are mean (SD)

* Sign diff car vs bicycle

Results:

- Minute Ventilation (VE): Bike/car ratio

Values are mean (SD)
Results: Inhaled quantities: bicycle/car ratio

Values are mean (SD)

- bike/car PNC, PM ratio = \approx 1
- bike/car VE ratio = 4.3
- inhaled particles by cyclists 400 - 900% higher compared to car passengers on the same trajectory
PM²TEN – Effect of cycling on Health outcomes

- Cross-over experiment: examine the acute effect of exercise on plasma BDNF, Exhaled nitric oxide (NO), plasma interleukin-6 (IL-6), platelet function, Clara cell protein in serum and blood cell counts when cycling in Polluted Environment (Antwerp ring) + Clean Room and examine the potential effect-modification by exposure to traffic-related air pollution.

Antwerp ring

Clean room

Results – PM10, PM2.5, UFP

Table 2 Exposure measurements during the road test and in the clean room

<table>
<thead>
<tr>
<th>Endpoint</th>
<th>Road test</th>
<th>Clean room</th>
<th>p-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average PM_{10} [µg/m³]</td>
<td>628 (258)</td>
<td>7.6 (1.6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Average PM_{2.5} [µg/m³]</td>
<td>24.7 (8.7)</td>
<td>2.6 (0.7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Average UFP [particles/cm³]</td>
<td>38,007 (677)</td>
<td>496 (38)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Duration of cycling [min]</td>
<td>20.8 (1.6)</td>
<td>20.2 (1.0)</td>
<td>0.20</td>
</tr>
<tr>
<td>Temperature [°C]</td>
<td>19.2 (1.6)</td>
<td>21.6 (1.0)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Relative humidity [%]</td>
<td>37.0 (14.3)</td>
<td>40.7 (14.0)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Heart rate [beats/min]</td>
<td>131 (15.0)</td>
<td>136 (14.4)</td>
<td>0.90</td>
</tr>
<tr>
<td>% of maximal heart rate</td>
<td>74.0% (6.6)</td>
<td>74.7% (6.8)</td>
<td>0.60</td>
</tr>
</tbody>
</table>

Values are Mean (SD), *Mixed model test.
Results - BDNF

Fig. 3. Serum BDNF concentrations (ng/mL) before and after cycling in the road test and the clean room test (mean ± SD). Serum BDNF concentrations were significantly different (*p = 0.043). BDNF concentrations increased significantly after cycling in the clean room (**p = 0.02; n = 35).

Results - Exhaled nitric oxide (NO), blood parameters

Table 4 Percent change [pre/post-cycling] in endpoints per exposure scenario (road test or clean room)

<table>
<thead>
<tr>
<th>Endpoint</th>
<th>Pre to post (%)</th>
<th>p-value</th>
<th>Pre to post (%)</th>
<th>p-value</th>
<th>Exposure scenario</th>
<th>p-value for interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exhaled NO</td>
<td>-4.4% (-8.3% to -0.37%)</td>
<td>0.04</td>
<td>-3.3% (-6.5% to 4.9%)</td>
<td>0.63</td>
<td>0.03</td>
<td>0.63</td>
</tr>
<tr>
<td>PEF closure time</td>
<td>6.5% (1.0% to 14.9%)</td>
<td>0.10</td>
<td>5.3% (1.0% to 11.6%)</td>
<td>0.11</td>
<td>0.76</td>
<td>0.60</td>
</tr>
<tr>
<td>Plasma NO</td>
<td>17.4% (6.7% to 47.9%)</td>
<td>0.18</td>
<td>-2.9% (-19.3% to 15.4%)</td>
<td>0.75</td>
<td>0.21</td>
<td>0.38</td>
</tr>
<tr>
<td>Eosinophil count</td>
<td>1.0% (0.0% to 15.8%)</td>
<td>0.02</td>
<td>0.27% (11.7% to 12.7%)</td>
<td>0.97</td>
<td>0.90</td>
<td>0.51</td>
</tr>
<tr>
<td>Blood leukocyte counts</td>
<td>1.3% (2.0% to 4.6%)</td>
<td>0.44</td>
<td>2.5% (1.4% to 6.0%)</td>
<td>0.19</td>
<td>0.75</td>
<td>0.37</td>
</tr>
<tr>
<td>Blood neutrophil counts</td>
<td>4.6% (4.48% to 8.27%)</td>
<td>0.04</td>
<td>2.48% (2.3% to 7.2%)</td>
<td>0.32</td>
<td>0.86</td>
<td>0.35</td>
</tr>
<tr>
<td>Percentage blood neutrophils</td>
<td>3.9% (1.5% to 6.2%)</td>
<td>0.003</td>
<td>0.22% (1.8% to 2.2%)</td>
<td>0.83</td>
<td>0.004</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Analysis adjusted for temperature, relative humidity and heart rate.

* p-value for the interaction between pre/post-cycling measurements and exposure scenario (road test or clean room).

† p-value for the interaction between pre/post-cycling measurements and UFP concentrations.

‡ p-value for the interaction between pre/post-cycling measurements and PM10 concentrations.
Cycling to work

Commuter Cycling

Health benefits/PA

Accidents

Air Pollution

Environmental & Psycho-social

Cost-benefit analysis

/ Health Impact Assessment
Predictive models – population level

Car driver → cyclist
Anno: 2016

Net health benefit: 7 months

→ 500,000 car drivers make a transition from car to bicycle for short trips (7.5-15 km) on a daily basis in the Netherlands

<table>
<thead>
<tr>
<th>Stressor</th>
<th>Relative risk</th>
<th>Gain in life years&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Gain in life days/ months per person&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air pollution</td>
<td>1.001 to 1.063</td>
<td>-1,106 to -65,163</td>
<td>-28 to -21 days</td>
</tr>
<tr>
<td>Traffic accidents</td>
<td>0.995 to 1.010&lt;sup&gt;b&lt;/sup&gt;</td>
<td>-6,422 to -12,856</td>
<td>-5 to -7 days</td>
</tr>
<tr>
<td>Physical activity</td>
<td>0.990 to 0.999</td>
<td>564.784 to 111.037</td>
<td>14 to 3 months</td>
</tr>
</tbody>
</table>

<sup>a</sup> Gain in life years is calculated using the formula: Gain = (1 - Relative risk) × 100

<sup>b</sup> Gain in life days/ months per person is calculated using the formula: Gain = (1 - Relative risk) × 365

CONCLUSIONS: On average, the estimated health benefits of cycling were substantially larger than the risks relative to car driving for individuals shifting their mode of transport.

de Hartog et al. (2010)
Net DALY: 19.5 annually

Now: 33% trips in Copenhagen by bicycle
→ 50% car trips 2-10 km & 33% car trips 10-15 km to cycling → cyclists to 42%

Holm et al. (2012)

Economic cost: health

• Shift car → bicycling, by evaluating 4 effects:
  – health benefit by PA
  – public health benefit due to reduced pollution
  – individual exposure to ambient air pollution
  – individual risk of accidents

→ Health → €€

Rabl & de Nazelle (2012)
Economic cost: health

- Estimated mortality costs and benefits per individual switching from car to bicycle for work trips* in large European cities

*Rab & de Nazelle (2012)

Economic cost: ‘other’ impacts

Typical benefits per individual who switches from driving to bicycling, €/yr

- Other impacts
- Reduced CO2, @ 25€/tonne CO2
- Nonfatal accident of individual
- Reduced noise, @ 0.76 €/km
- Reduced congestion, @ 0.73 €/km

Fig. 3. Comparison of mortality costs and benefits with other impacts, for our bicycling scenario.

Rab & de Nazelle (2012)
Total Economic benefit: 177 M€/yr

- Vélib Program in Paris:
  - total cost of the program is 64 M€/yr (2011)

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount, M€/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health gain from bicycling</td>
<td>52.4</td>
</tr>
<tr>
<td>Public gain from reduced pollution</td>
<td>1.3</td>
</tr>
<tr>
<td>Pollution exposure of individual</td>
<td>-0.7</td>
</tr>
<tr>
<td>Fatal accidents</td>
<td>-4.2</td>
</tr>
<tr>
<td>Nonfatal accidents</td>
<td>-11.5</td>
</tr>
<tr>
<td>Reduced CO₂ emissions</td>
<td>0.5</td>
</tr>
<tr>
<td>Congestion</td>
<td>69.0</td>
</tr>
<tr>
<td>Noise</td>
<td>69.0</td>
</tr>
<tr>
<td>Total benefit</td>
<td>176.0</td>
</tr>
</tbody>
</table>

Rabl & de Nazelle (2012)

Economic cost: infrastructure

- transport infrastructure or policy + walking and/or cycling and health effects

- variation in values attributed to 1 new active walker/cyclist: €127 - €1290/year

Cavill et al. (2008)
Economic cost: infrastructure

- By 2040, investments M$138 to M$605 result:
  - health care cost savings: M$388 to M$594
  - fuel savings: M$143 to M$218
  - savings in value of statistical lives: $7 to $12 billion
- BCR for health care and fuel savings: 3.8:1 - 1.2:1
- order of magnitude larger when value of statistical lives is used

Gotchi (2011)

Health impact assessment of active transportation: A systematic review

Mueller (2015)
THANK YOU FOR YOUR ATTENTION

prof dr Bas de Geus
Human Physiology Research Group (MFYS)
Pleinlaan 2, B-1050 BRUSSELS – BELGIUM
[T] +32 (0)2 629 27 54
[E] bas.de.geus@vub.ac.be
[W] www.blits.org