Does physical activity prevent weight gain and development of obesity ?

-

An Epidemiological Perspective

Belgian Association for the Study of Obesity
February 9th 2019

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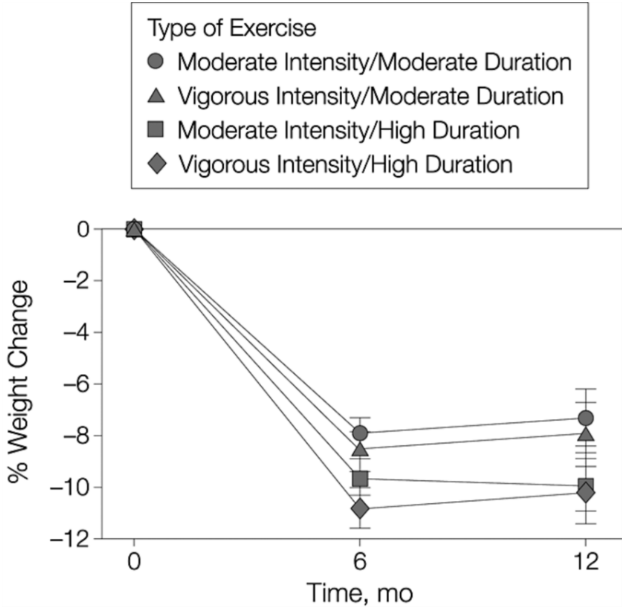
Physical Activity / Exercise and body weight – Complex issues

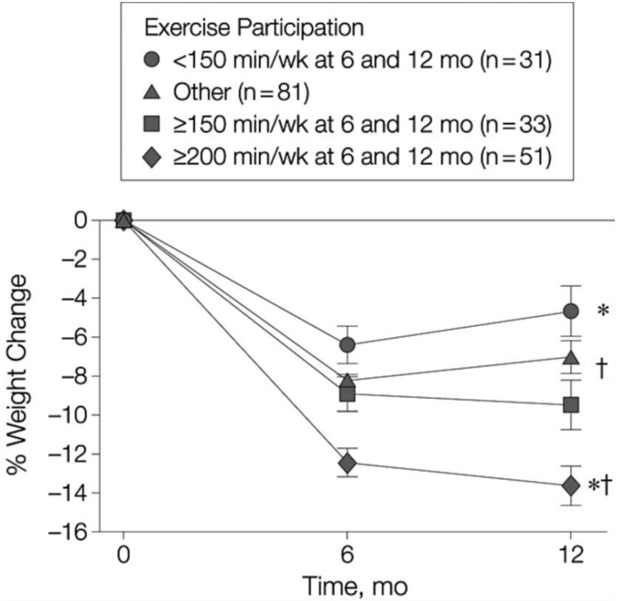
- Physical activity for reducing body weight
- Physical activity in those with over-weight and obesity – health benefits?
- Physical activiy for preventing weight gain
- Physical activity for preventing development of obesity
- Physical activity and health independent of body weight

PHYSICAL ACTIVITY AND WEIGHT LOSS

Effect of Exercise Duration and Intensity on Weight Loss in Overweight, Sedentary Women

201 women with BMI of 32.6 randomised into 4 groups and advised to reduce EI to 1200-1500 kcal/d





- **No Difference between exercise intensities and durations in weight loss**
- **Participation was associated with weight loss**

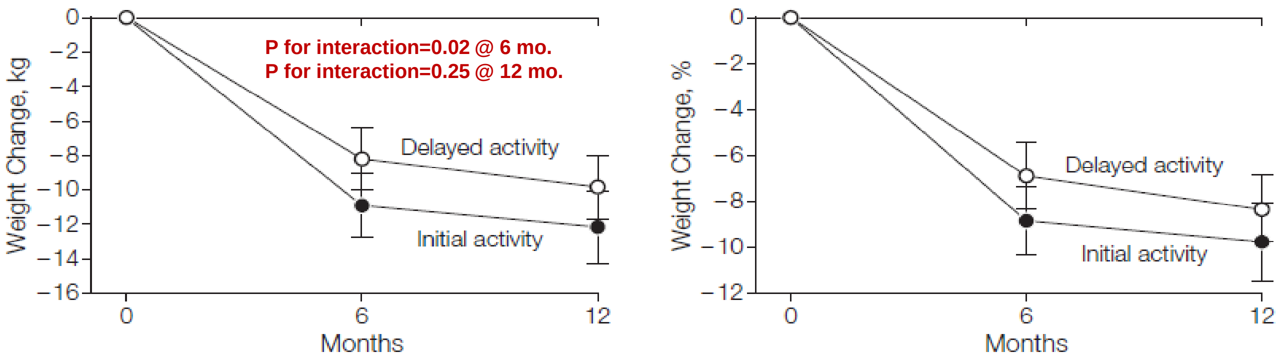
(Jakicic et al, JAMA 2004)

Effects of Diet and Physical Activity Interventions on Weight Loss and Cardiometabolic Risk Factors in Severely Obese Adults

A Randomized Trial

130 severely obese adults (BMI>35) randomised into 1) diet + PA for 12 months (initial PA group) and 2) diet 12 months + PA 6 months (delayed PA)
Intervention mainly included walking (>10,000 steps/d) EI reduced to obtain weight loss of 8-10%

Figure 2. Absolute and Percentage Weight Loss in Initial Physical Activity and Delayed Physical Activity Groups

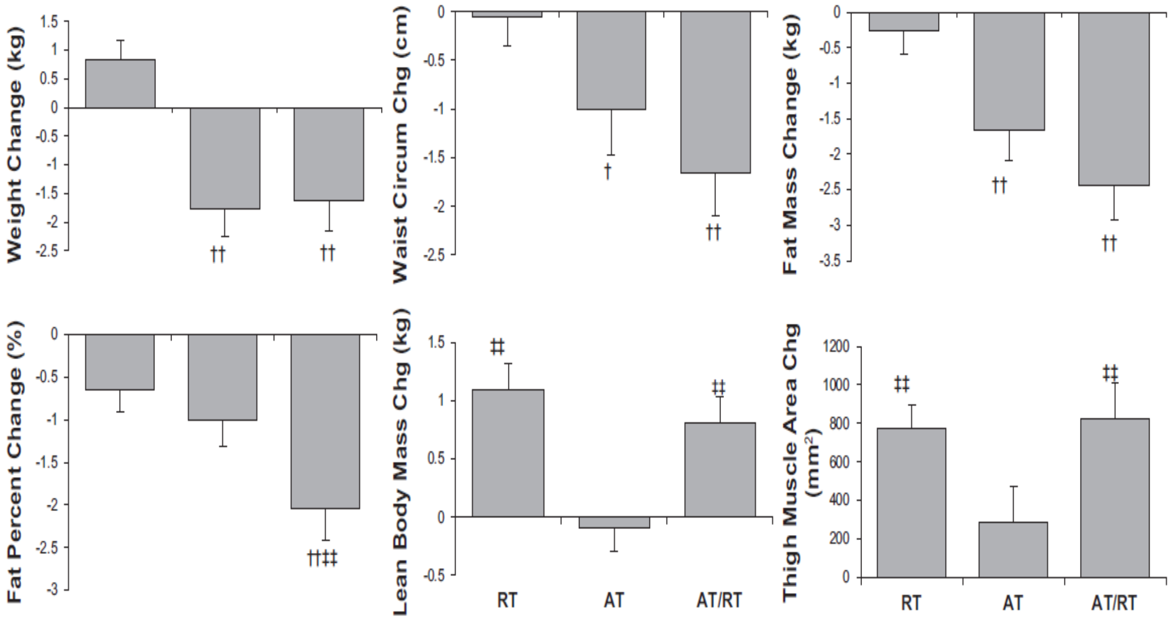


- **Weight change mainly due to diet**
- **Exercise + Diet promoted greater weight loss at 6 months but not 12 months**

(Goodpaster et al, JAMA 2010)

Effects of aerobic and/or resistance training on body mass and fat mass in overweight or obese adults

119 adults (mean BMI >30) randomised into RT, AT and RT+AT
RT: 3 times/week, 3 sets/d, 8-12 reps;
AT: 3 times/week; 40 min of 65-80% of VO_{2max}



- **AT and RT+AT reduced body weight, WC and FM significantly more than RT**
- **RT and RT+AT increased LBM significantly more than AT**
- **Balancing the time commitments against health benefits, AT appears optimal for reducing BW and FM while RT is needed to increase LBM in obese individuals**

(Willis et al, JAP 2012)

Effect of exercise with no weight change

- 20 RCT in over-weight and obese men + women without caloric restriction and <3% weight loss
- 60 to >400 min/week for 6 to 64 weeks
- 75% of the RCT reported significant improvements in CVD risk factors (HDL, LDL, Chol, TG, IS, BP, HbA1c)
- 11 of 17 studies reported significant reductions in WC or visceral fat
- 13 of 19 studies reported significant improvements in VO_{2max} (0.7 – 10.0 mLO_2/kg/min)
- Significant heath benefits without change in body weight

(Ross & Bradshaw, *Nat Rev Endocrinol* 2009)

Summary

- Exercise + Diet interventions = weight reduction (20% / 80%)
- Exercise interventions without caloric restriction induces modest reductions in body weight
- Exercise has acute effects on "all" metabolic risk factors
- Individuals respond differently to an exercise intervention
- Exercise interventions induces improvements in metabolic risk factors independent of weight loss

The Epidemiological Perspective – Does physical activity prevent weight gain on population level

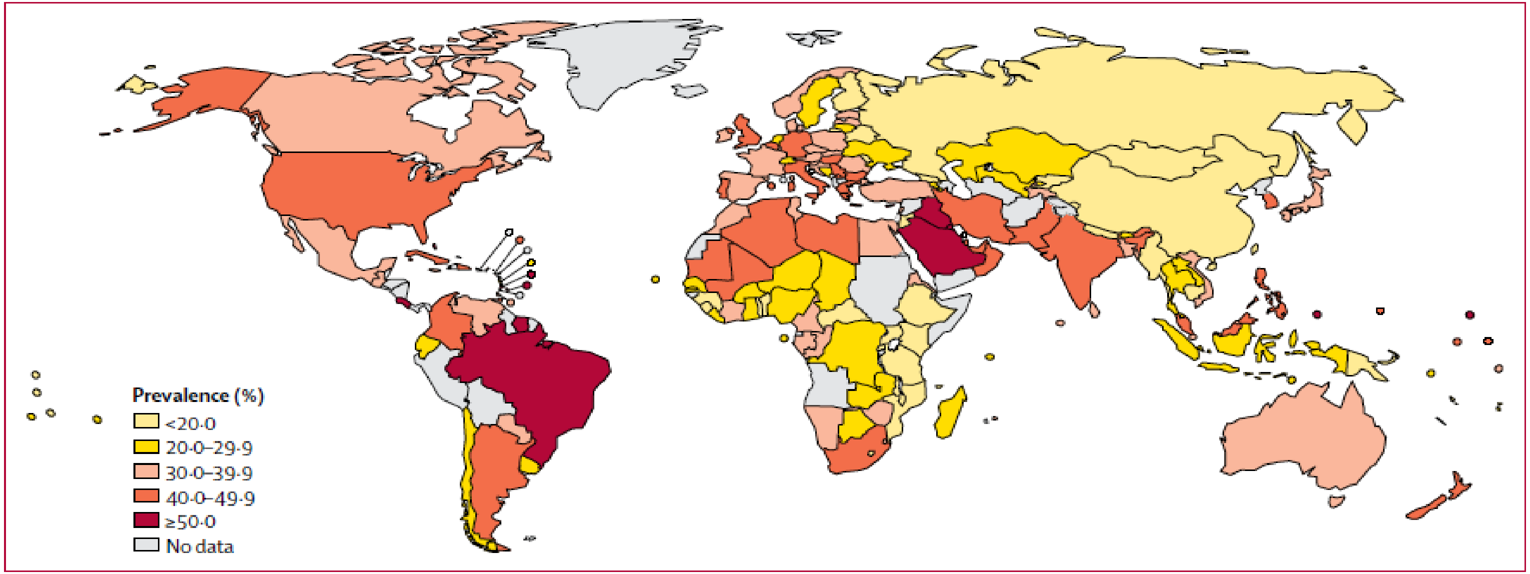
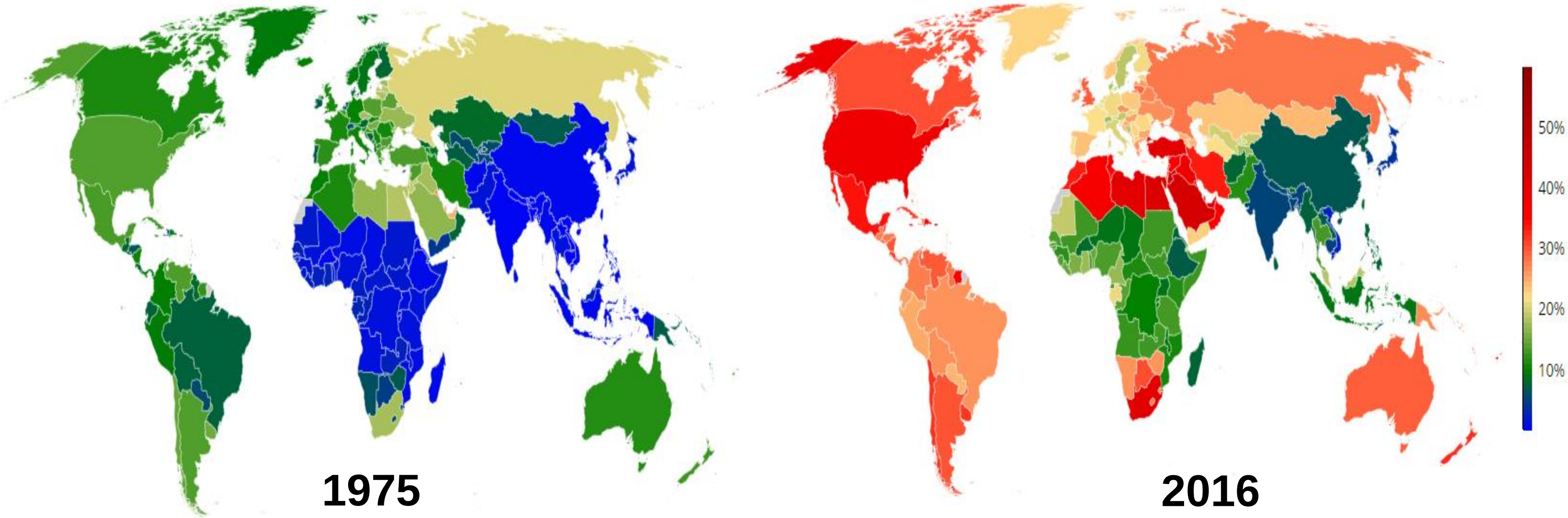


Figure 5: Country prevalence of insufficient physical activity in women in 2016

(Guthold et al, Lancet Publ Health 2018)

Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128·9 million children, adolescents, and adults



(NCD Risk Factor Collaboration, The Lancet 2017;390:2627-42)

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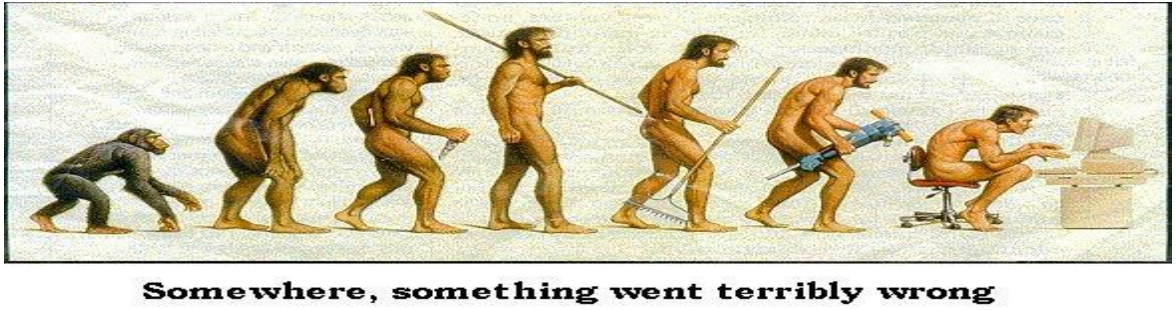
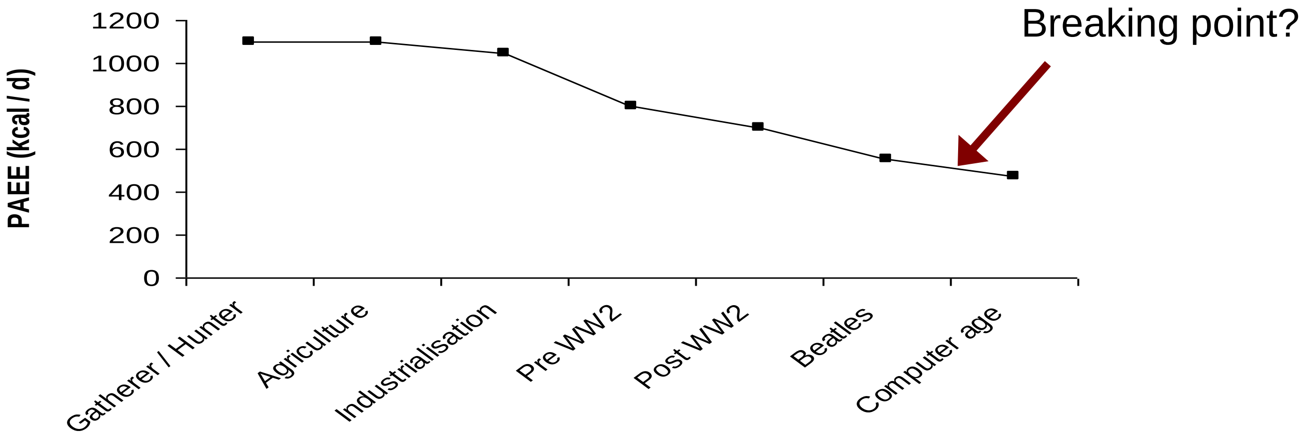
Decline in habitual physical activity?





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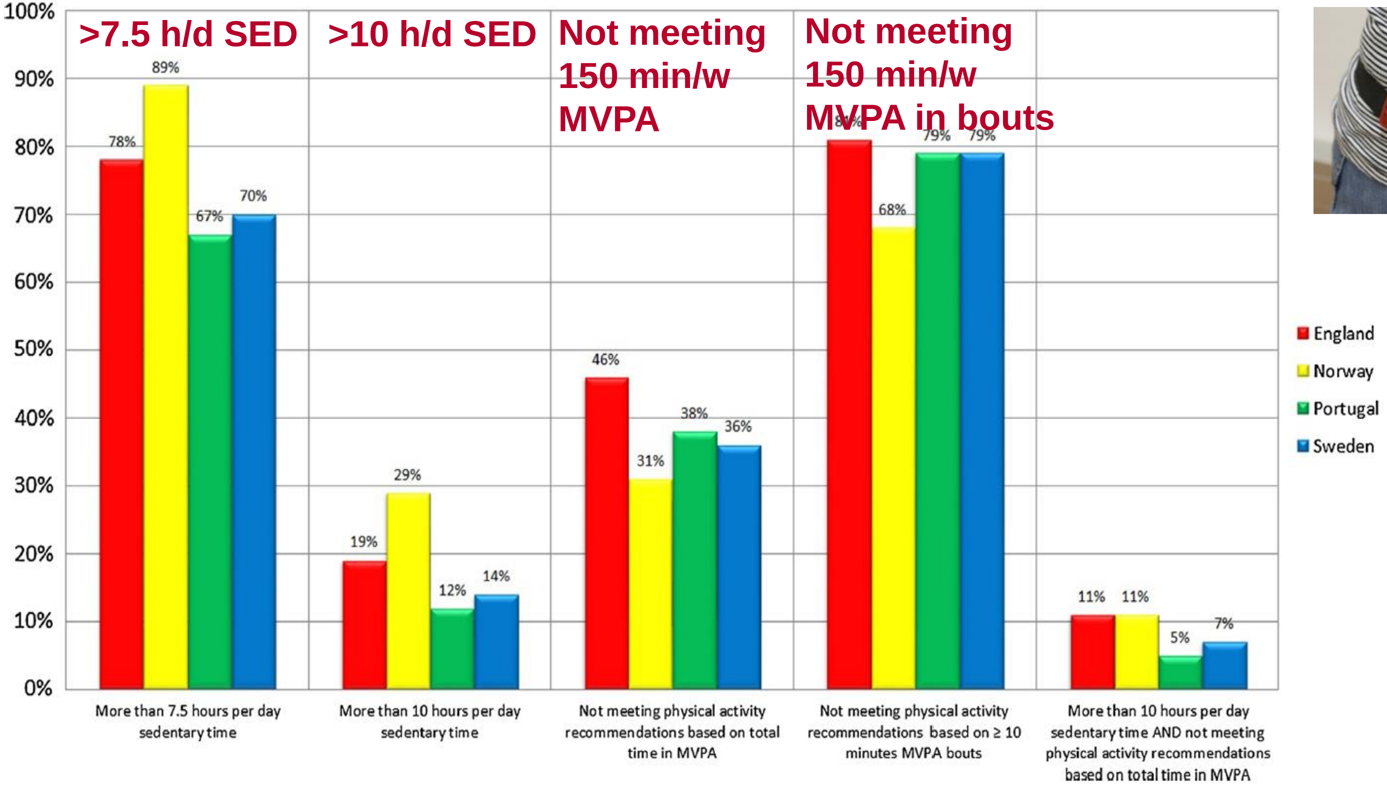
Sedentary Time and Physical Activity Surveillance Through Accelerometer Pooling in Four European Countries



(Loyen et al, Sports Med 2017)

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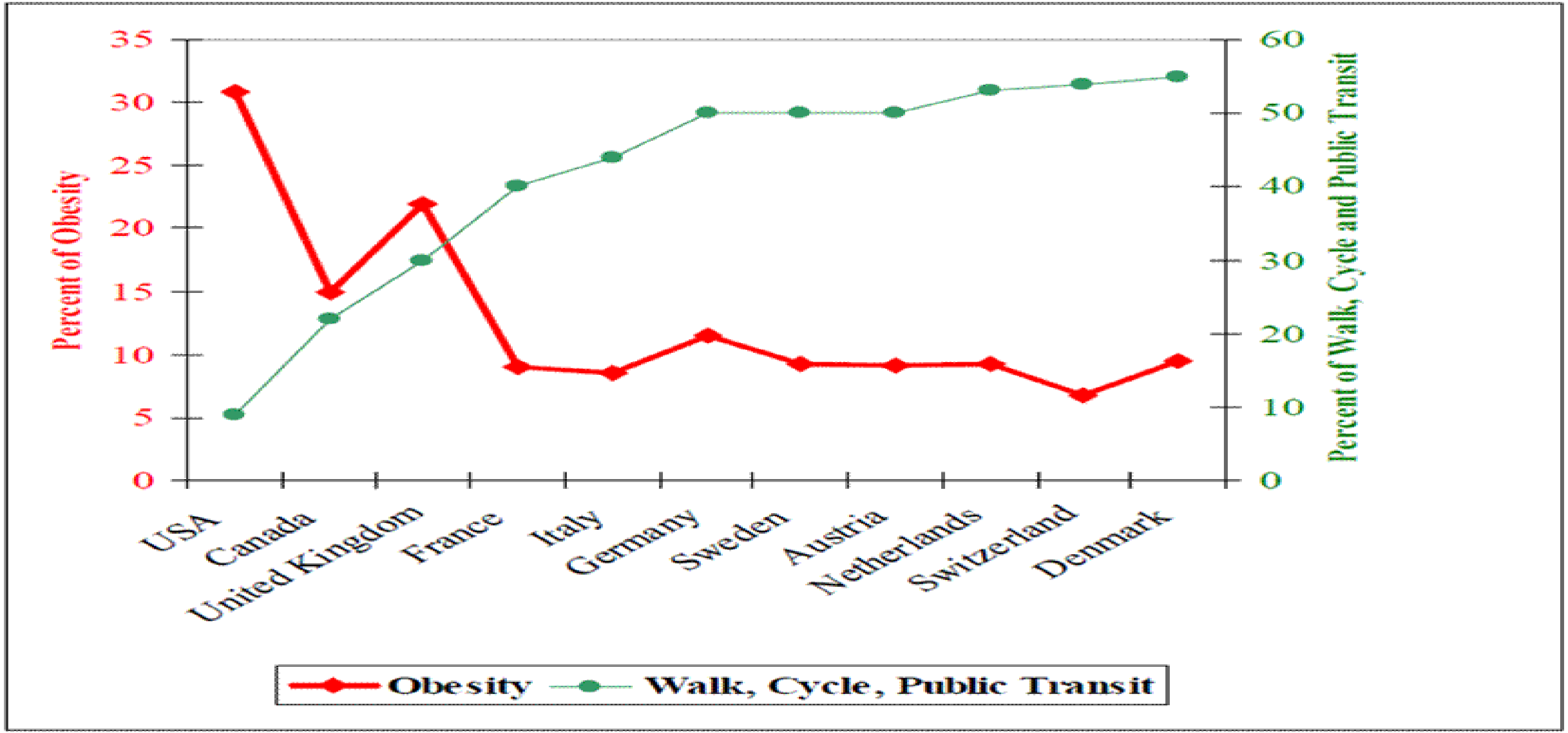
Ecological observations

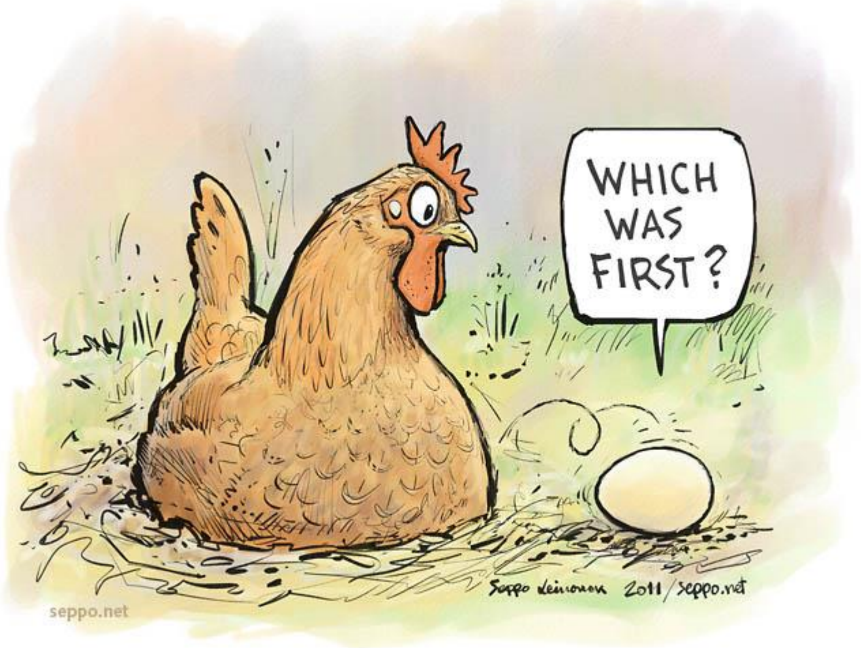


(McCann, 2010)

Correlation does not imply causation!

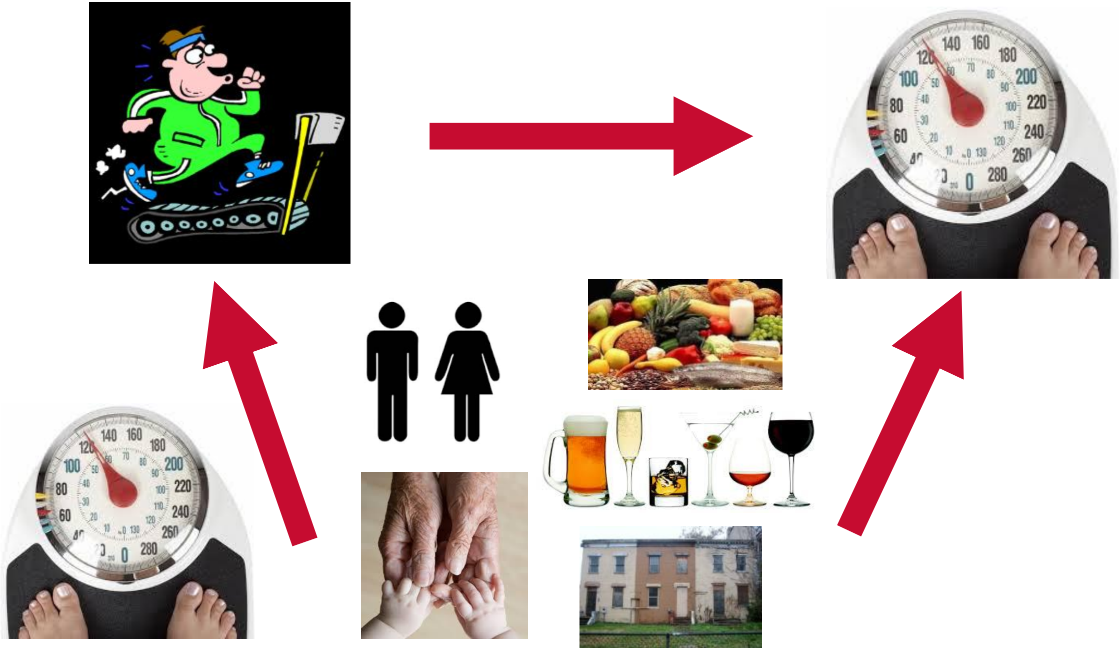
- **Ecological data on time trends in obesity and physical activity cannot be used to infer causality**

- **Cross-sectional data canot be used to infer causality**



Does physical activity prevent weight gain?

Baseline Physical Activity | **Follow up Body Weight**



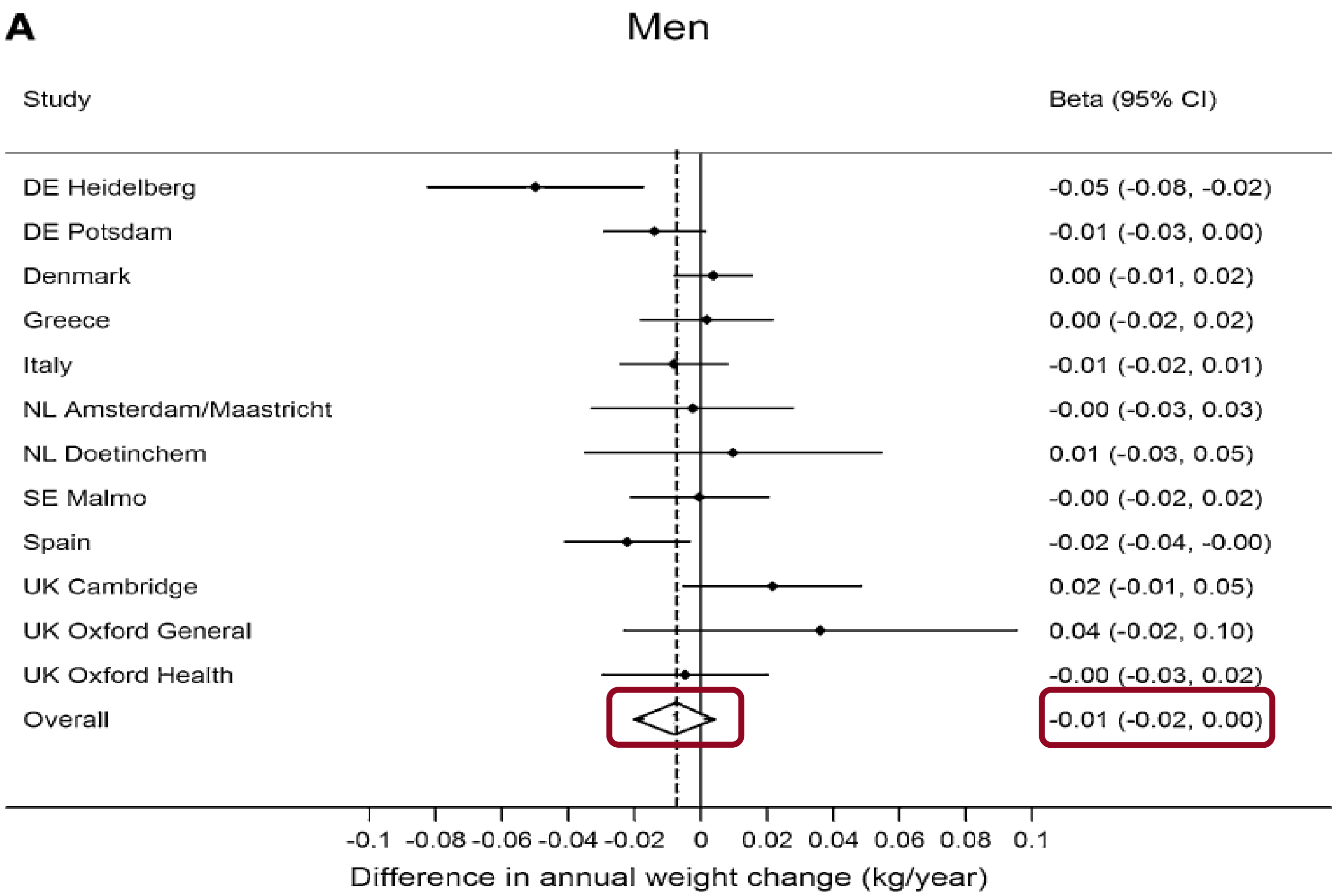
This model determines the direction of association

Physical activity and gain in abdominal adiposity and body weight: prospective cohort study in 288,498 men and women[1–4]

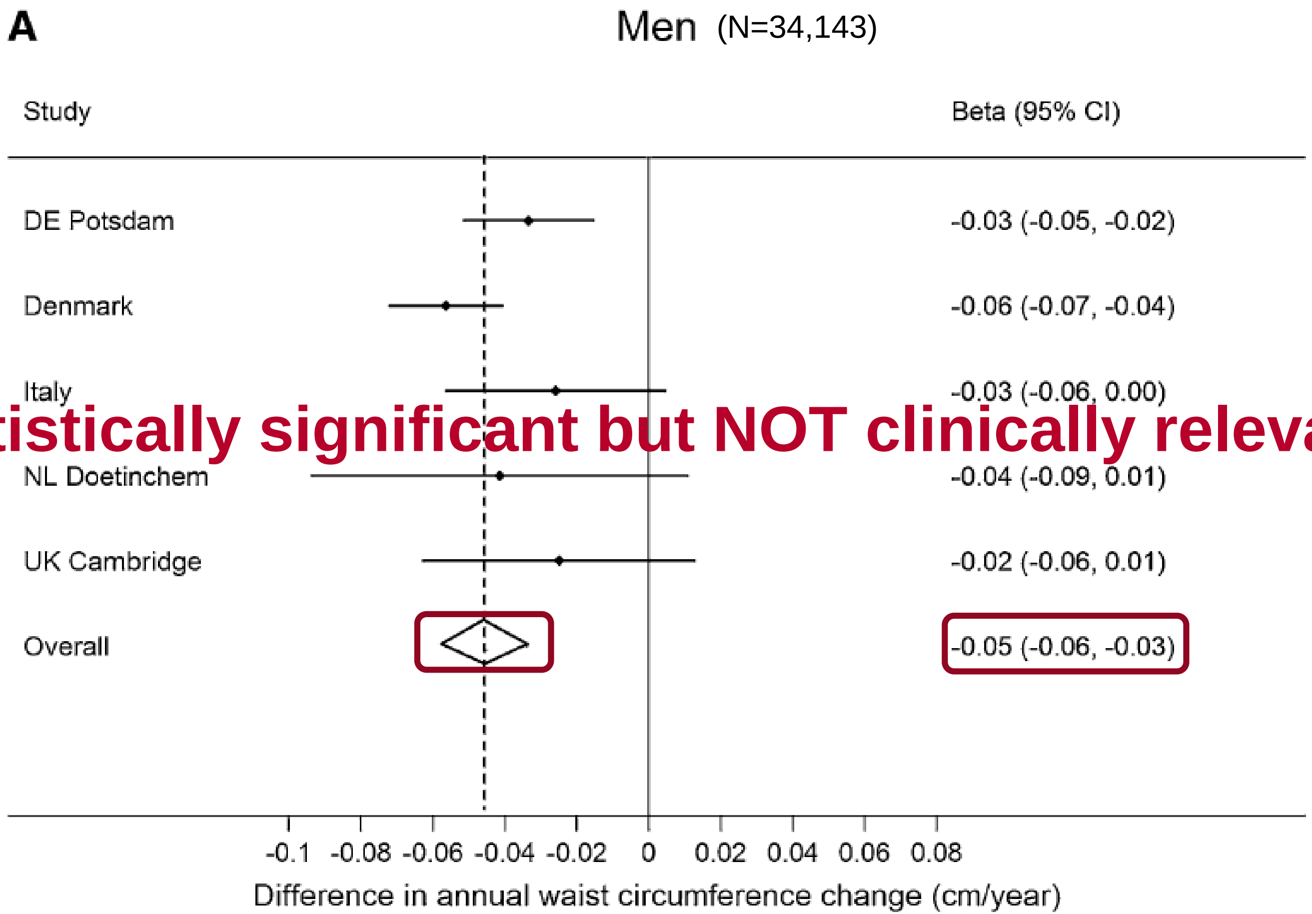
- 5.1 yrs folllow-up
- 25-79 years
- **Main Outcomes**: Weight and waist circumference at FU
- **Exposure**: PA index
- **Covariates**: age, smoking, alcohol, education, energy intake, FU time, baseline BW or WC

Work activity	Leisure time physical activity (Duration of sport and cycling in hrs/wk)			
	No	≤3.5	>3.5 and ≤7.0	> 7.0
Sedentary	Inactive	Moderately inactive	Moderately active	Active
Standing	Moderately inactive	Moderately active	Active	Active
Manual	Moderately active	Active	Active	Active
Heavy manual	Active	Active	Active	Active

(Ekelund et al, *AJCN* 2011;93:826-35)



(Ekelund et al, *AJCN* 2011;93:826-35)



Statistically significant but NOT clinically relevant

(Ekelund et al, *AJCN* 2011;93:826-35)

Objective monitoring of activity and sedentary

Objectively measured sedentary time and physical activity and associations with body weight gain: does body weight determine a decline in moderate and vigorous intensity physical activity?

- Randomly selected population based sample of Norwegian adults (20-85 yrs.)
- Physical activity and sedentary time measured with accelerometery in 2008-09 (N=3207) and again in 2014-15 (N=1929 [60%], 45.8% men)
- Body weight and height
- SES, diet, health, alcohol, smoking self-reported
- Covariates: baseline value of the outcome, sex, SES, age, diet, alcohol, wear time and season

(Ekelund et al, Int J Obes 2017;41:1769-76)

Objective monitoring of activity and sedentary

Baseline MVPA

Follow up Body Weight

B= -0.02 (95% CI; -0.015; 0.011) for a 10 min difference

(Ekelund et al, Int J Obes 2017;41:1769-76)

Objective monitoring of activity and sedentary

Baseline Sedentary time

Follow up Body Weight

B= 0.03 (95% CI; -0.007; 0.002) for a 10 min difference

(Ekelund et al, Int J Obes 2017;41:1769-76)

Does weight status predict physical inactivity? (Reverse causality)

Baseline Weight

Follow up Activity

Baseline Activity

Direction of association –
Objective monitoring of activity and sedentary

Baseline Weight

B= -1.1 (95% CI, -0.22; -0.02)
10 kg BW difference predicted
1 min lower MVPA

Follow up MVPA

Follow up SED

B= 0.23 (95% CI, -0.06; 0.53)

(Ekelund et al, Int J Obes 2017)

Weight gain is associated with lower activity

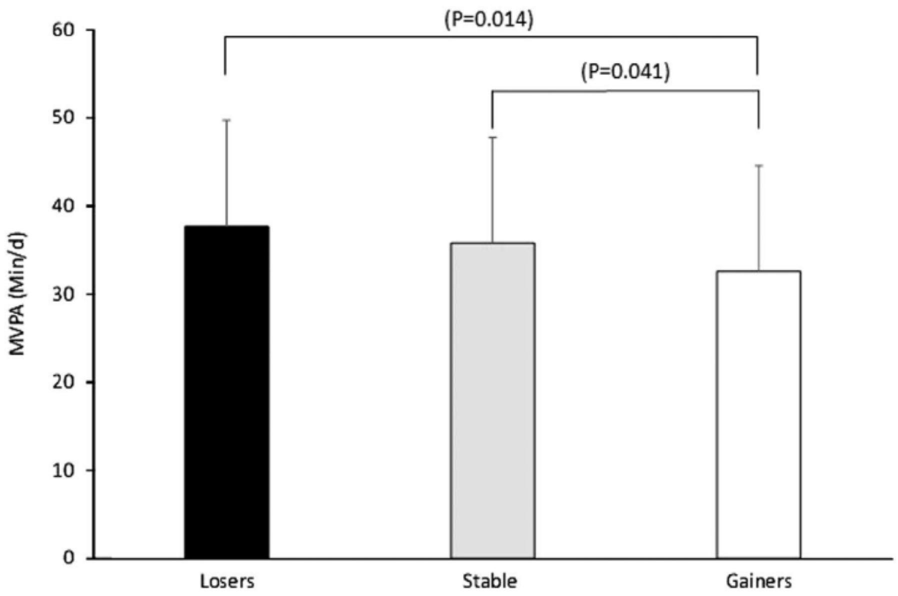


Figure 1. Time spent in MVPA in weight gainers (>5% of body weight), weight-stable and weight losers (>5% of body weight) at follow-up. Data are adjusted for sex, age, baseline body weight, sleep duration, alcohol consumption, smoking, education, wear time, and time spent in MVPA ($N = 1579$).

(Ekelund et al, Int J Obes 2017)

Sedentary time, physical activity, and adiposity in a longitudinal cohort of nonobese young adults

- **Aim**: Examine association between sedentary time and MVPA with fat mass in non-obese young adults
- **Design**: 2 year prospective study
- **Methods**: Accelerometry, DXA
- **Results**: > 8 h/day sedentary associated with higher fat mass and >30 min MVPA/day associated with lower FM at baseline. **NO** associations in prospective analyses
- **Conclusion**: **High Sedentary time and low MVPA did not predict change in adiposity**

(Staiano et al, AJCN, 2018)

Discussion – direction of association

- **Measurement precision of the exposure and outcome**

  - the use of an imprecise measure of an exposure (physical activity) variable will tend to systematically underestimate its relationship with an outcome variable – *regression dilution*

  - imprecision in the outcome variable (physical activity) increase the uncertainty in the estimate of the effect size and does not result in systematic underestimation of the association

  - Be cautious when interpreting associations when exposures and outcomes are measured with different degree of precision

Mendelian Randomization – Inference about Causality

MR design control for confounding and reverse causation

Obesity

Physical Activity / Sedentary

SNPs associated with obesity
(FTO, ...) ”Genetic risk score”

<u>Key Assumptions - MR</u>
Genotypes randomised
Instrumental variable affecting the outcome only by modifying the ”biomarker” (pleitrophy)
Genotype independent of confounders

(Lawlor et al, *Stats Med* 2008)

Assessing Causality in the Association between Child Adiposity and Physical Activity Levels: A Mendelian Randomization Analysis

Methods and Findings: The Avon Longitudinal Study of Parents and Children collected data on objectively assessed activity levels of 4,296 children at age 11 y with recorded BMI and genotypic data. We used 32 established genetic correlates of BMI combined in a weighted allelic score as an instrumental variable for adiposity to estimate the causal effect of adiposity on activity. In observational analysis, a 3.3 kg/m^2 (one standard deviation) higher BMI was associated with 22.3 (95% CI, 17.0, 27.6) movement counts/min less total physical activity ($p = 1.6 \times 10^{-16}$), 2.6 (2.1, 3.1) min/d less moderate-to-vigorous-intensity activity ($p = 3.7 \times 10^{-29}$), and 3.5 (1.5, 5.5) min/d more sedentary time ($p = 5.0 \times 10^{-4}$). In Mendelian randomization analyses, the same difference in BMI was associated with 32.4 (0.9, 63.9) movement counts/min less total physical activity ($p = 0.04$) (~5.3% of the mean counts/minute), 2.8 (0.1, 5.5) min/d less moderate-to-vigorous-intensity activity ($p = 0.04$), and 13.2 (1.3, 25.2) min/d more sedentary time ($p = 0.03$). There was no strong evidence for a difference between variable estimates from observational estimates. Similar results were obtained using fat mass index. Low power and poor instrumentation of activity limited causal analysis of the influence of physical activity on BMI.

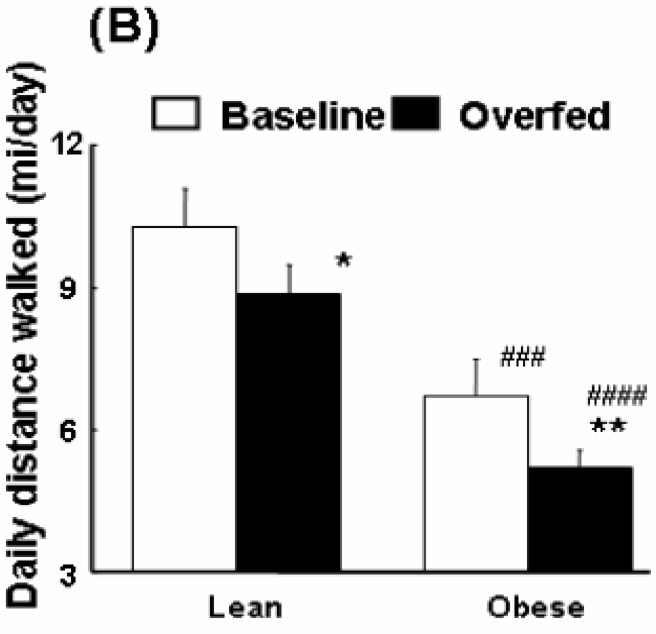
Conclusions: Our results suggest that increased adiposity causes a reduction in physical activity in children and support research into the targeting of BMI in efforts to increase childhood activity levels. Importantly, this does not exclude lower physical activity also leading to increased adiposity, i.e., bidirectional causation.

- **1 SD higher BMI associated with 2.6 min lower MVPA and 3.5 more min spent sedentary**
- **In MR analyses the associations were almost unchanged**
- **Poor instrumentation of activity limited causal analyses of the PA and BMI relationship**

(Richmond et al, PLOS Med 2014)

Free-living walking distance decreases after weight gain

- Over-feeding in obese and normal-weight individuals by 1000 kcal/d for 8 weeks (n=22)
- Weight gain 3.6 kg
- Lean individuals walked more at baseline (10.3 vs. 6.7 miles/d)
- Daily walking decreased significantly and to a similar degree in both groups (1.5 miles/d)



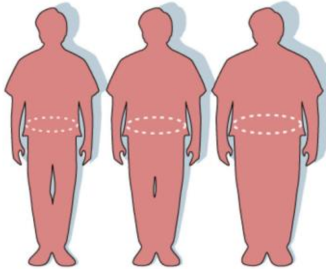
EXPERIMENTALLY INDUCED WEIGHT GAIN REDUCES PHYSICAL ACTIVITY

(Levine et al, Diabetes, 2008)

Does activity prevent development of obesity?

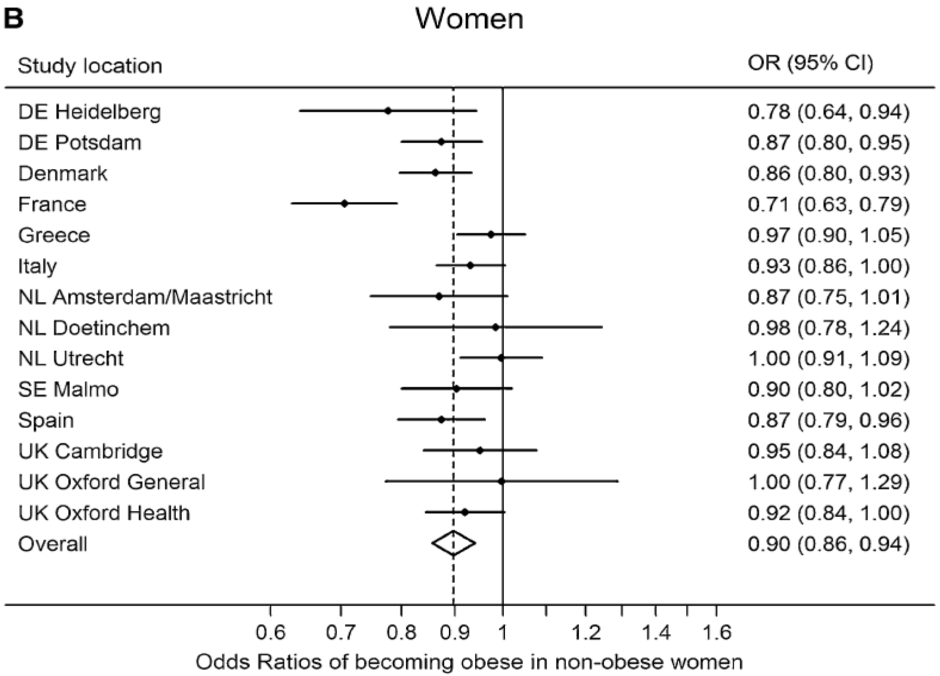
Baseline activity in those who are non-obese

Obesity at follow-up



Physical activity and gain in abdominal adiposity and body weight: prospective cohort study in 288,498 men and women[1–4]

5% of men and 4% of women become obese (BMI>30); the OR was reduced by 7% in men and 10% in women for a 1 category difference in PA index



(Ekelund et al, *AJCN* 2011)

Physical Activity and the Risk of Becoming Overweight or Obese in Middle-Aged and Older Women

Women's Health Study (N=19,003) followed for 11.6 years; 7865 become OW or Obese

Amount of weekly physical activity	Cases	Crude incidence rate (cases/10,000 person years)	Age-adjusted	Multivariable model[a]	Multivariable model + BMI[b]
Moderate physical activity					
None	489	530.4	1.0	1.0	1.0
<1,000 kcal	5,108	457.3	0.88 (0.80–0.96)	0.89 (0.81–0.98)	0.92 (0.84–1.01)
1,000–2,000 kcal	1,259	474.8	0.91 (0.82–1.01)	0.94 (0.84–1.05)	0.88 (0.79–0.99)
>2,000 kcal	287	514.3	0.97 (0.84–1.13)	1.03 (0.88–1.19)	0.93 (0.80–1.09)
P for trend			0.2	0.07	0.3
Vigorous physical activity					
None	4,216	498.9	1.0	1.0	1.0
<1,000 kcal	2,709	453.9	0.92 (0.87–0.96)	0.94 (0.90–0.99)	0.99 (0.94–1.04)
1,000–2,000 kcal	554	457.9	0.92 (0.84–1.00)	0.94 (0.86–1.02)	0.97 (0.88–1.06)
>2,000 kcal	346	382.1	0.77 (0.69–0.86)	0.79 (0.71–0.89)	0.95 (0.85–1.07)
P for trend			<0.0001	<0.0001	0.3

Vigorous intensity associated with lower risk of becoming overweight/obese

(Britton et al, Obesity 2012)

Summary

- The prospective association between physical activity and gain in body weight and BMI is weak – **not explained by measurement error?**

- The association between physical activity and weight gain is likely **bi-directional**

- **BMI is causally associated with lower levels of physical activity – Mendelian randomization!**

- The amount and intensity of activity needed to maintain a healthy body weight (Normal BMI) throughout life is **unknown but likely susbtantial**

Despite this, increasing population levels of physical activity is one of the (if not 'the ONE') most important lifestyle factor for improving public health

Physical activity and all-cause mortality across levels of overall and abdominal adiposity in European men and women: the European Prospective Investigation into Cancer and Nutrition Study (EPIC)[1–6]

- The **E**uropean **P**rospective **I**nvestigation into **C**ancer and Nutrition Study (**EPIC**)

Overall aim;

- to investigate the joint and independent associations between obesity, physical activity and mortality
- Prospective cohort study (n=519,978)
- 23 centres in 10 countries (1992-2000)

Present analysis

- Inclusion; No baseline disease, Clinically measured BMI and WC, PA assessed by self-report
- Final sample: N=334,161 (35% men)

(Ekelund et al, AJCN 2015;101:613-21)

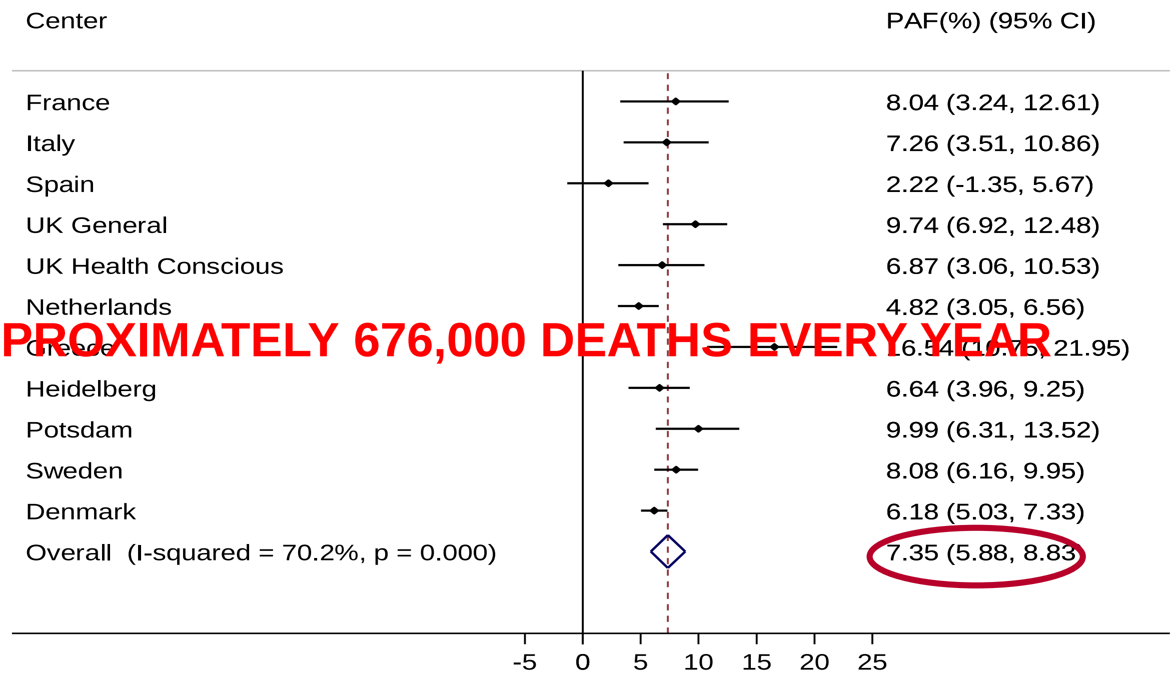
Risk of all-cause mortality within obesity groups

	Death (N)	Inactive	Moderately inactive	Moderately active	Active
BMI (kg/m²)					
18.5- 24.9	8285	1	0.76 (0.72 – 0.81)	0.71 (0.67 – 0.76)	0.65 (0.60 - 0.70)
25 - 29.9	8815	1	0.82 (0.77 – 0.86)	0.78 (0.73 – 0.83)	0.75 (0.70 – 0.80)
>30	4338	1	0.84 (0.78 – 0.91)	0.76 (0.69 – 0.84)	0.82 (0.74 – 0.90)
WC (cm)					
<88(W)/<102(M)	14362	1	0.80 (0.76 – 0.83)	0.76 (0.72 – 0.79)	0.71 (0.68 – 0.75)
≥88(W)/≥102(M)	7076	1	0.84 (0.79 – 0.89)	0.78 (0.73 – 0.84)	0.80 (0.73 – 0.86)

Data are Hazard ratios (95% CI) and adjusted for sex, age, study centre, education, smoking and alcohol
(P for interaction PA x BMI <0.001)

(Ekelund et al, AJCN 2015;101:613-21)

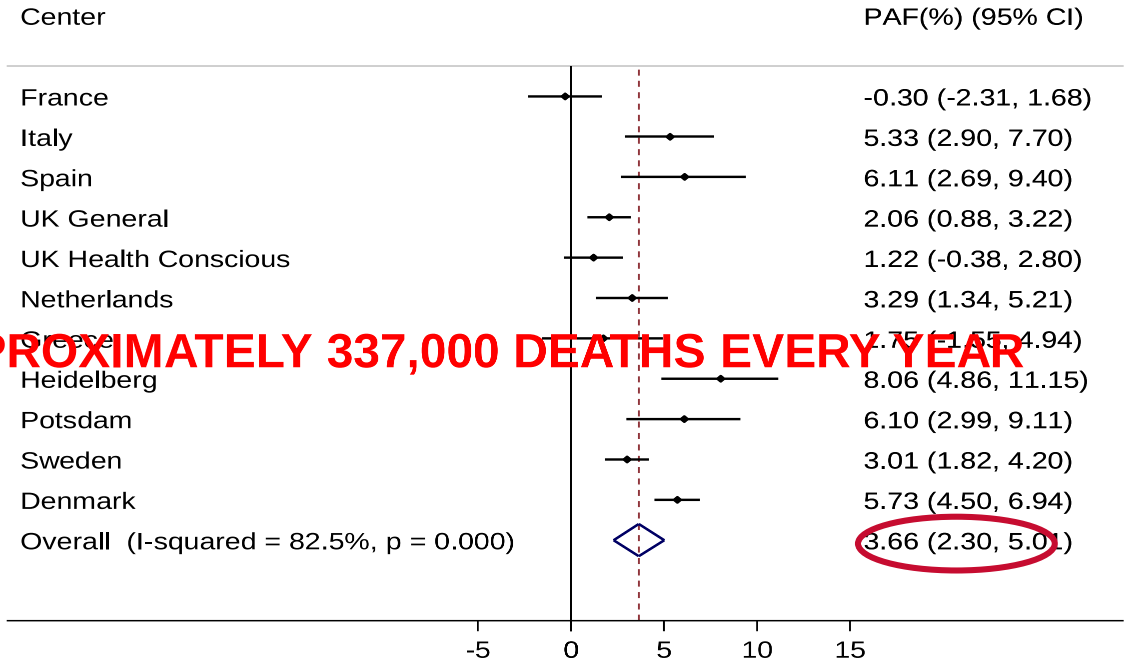
Proportion of deaths averted if inactivity was removed



Data adjusted for sex, age, education, smoking and alcohol

(Ekelund et al, AJCN 2015;101:613-21)

Proportion of deaths averted if obesity (BMI>30) was removed



APPROXIMATELY 337,000 DEATHS EVERY YEAR

Data adjusted for sex, age, education, smoking and alcohol

(Ekelund et al, AJCN 2015;101:613-21)

Does physical activity attenuate, or even eliminate, the detrimental association of sitting time with mortality? A harmonised meta-analysis of data from more than 1 million men and women

Ulf Ekelund, Jostein Steene-Johannessen, Wendy J Brown, Morten Wang Fagerland, Neville Owen, Kenneth E Powell, Adrian Bauman, I-Min Lee, for the Lancet Physical Activity Series 2 Executive Committe* and the Lancet Sedentary Behaviour Working Group*

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Sitting Is a Silent Killer, Swedish Medics Warn Couch Potatoes

By Michelle Fay Cortez - January 18, 2010 19:01 EST

Jan. 19 (Bloomberg) -- Desk jockeys and couch potatoes beware: Too much sitting, and not just a lack of exercise, may cause heart disease and other life-threatening illnesses, according to doctors from the Karolinska Institute and the Swedish School of Sport and Health.

Medical Daily

LAST UPDATED 03:02 AM EDT AUGUST 18, 2012

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Sitting More Than 11 Hours a Day Raises Premature Death Risk By 40%

People who sit for 11 hours or more a day are 40 percent more likely to die over the next three years, regardless of whether they are physically active or not, according to a new study.

BY CHRISTINE HSU | MARCH 27, 2012 Text Size

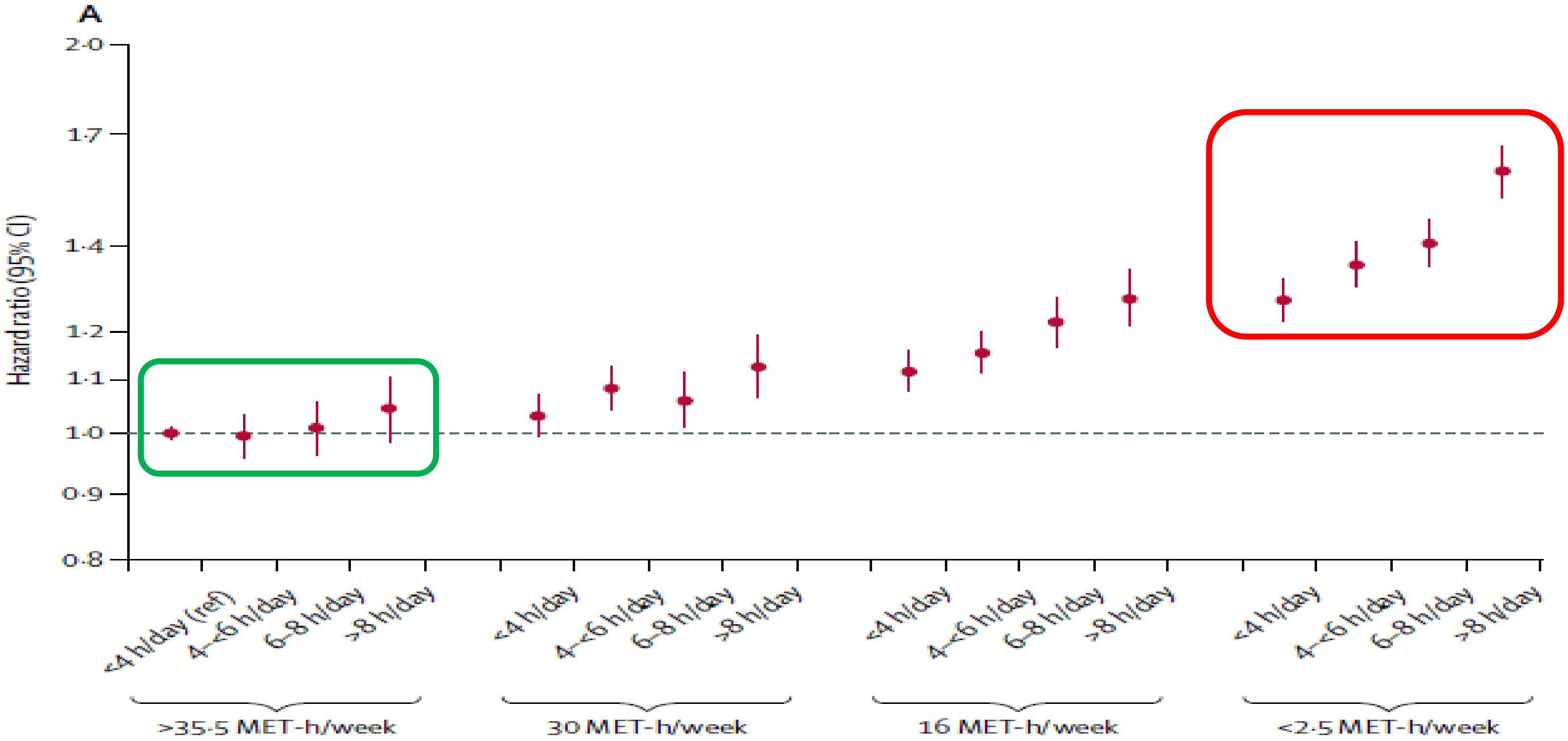
People who sit for 11 hours or more a day are 40 percent more likely to die over the next three years, regardless of whether they are physically active or not, according to a new study.

Researchers analyzed self-reported data from 222,497 people in Australia aged 45 years and older and found that the death risks peak after 11 hours of total daily sitting, but the death risk is still 15 percent higher for those sitting between eight to 11 hours a day compared to people sitting less than four hours a day.

"In conclusion, prolonged sitting is a risk factor for all-cause mortality. Shorter sitting times and sufficient physical activity are independently

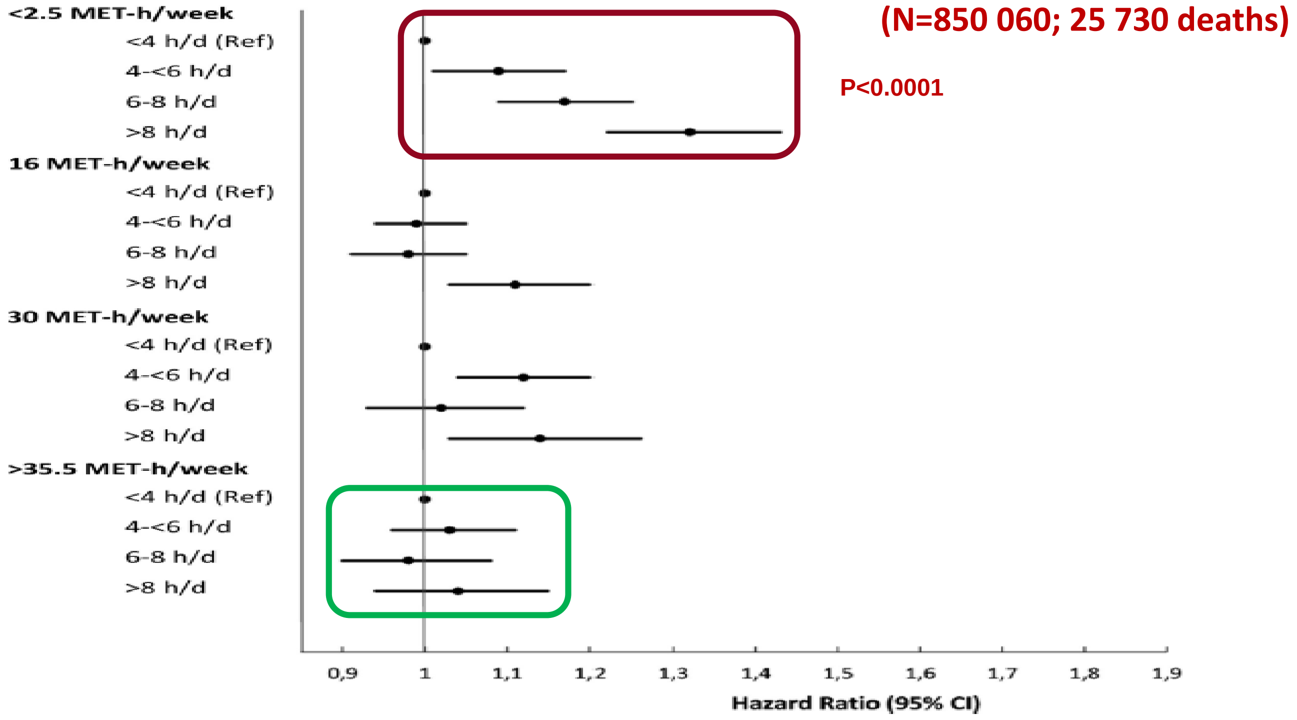
(Ekelund et al, Lancet 2016;388:1302-10)

Combined associations – Physical Activity, Sitting and Mortality



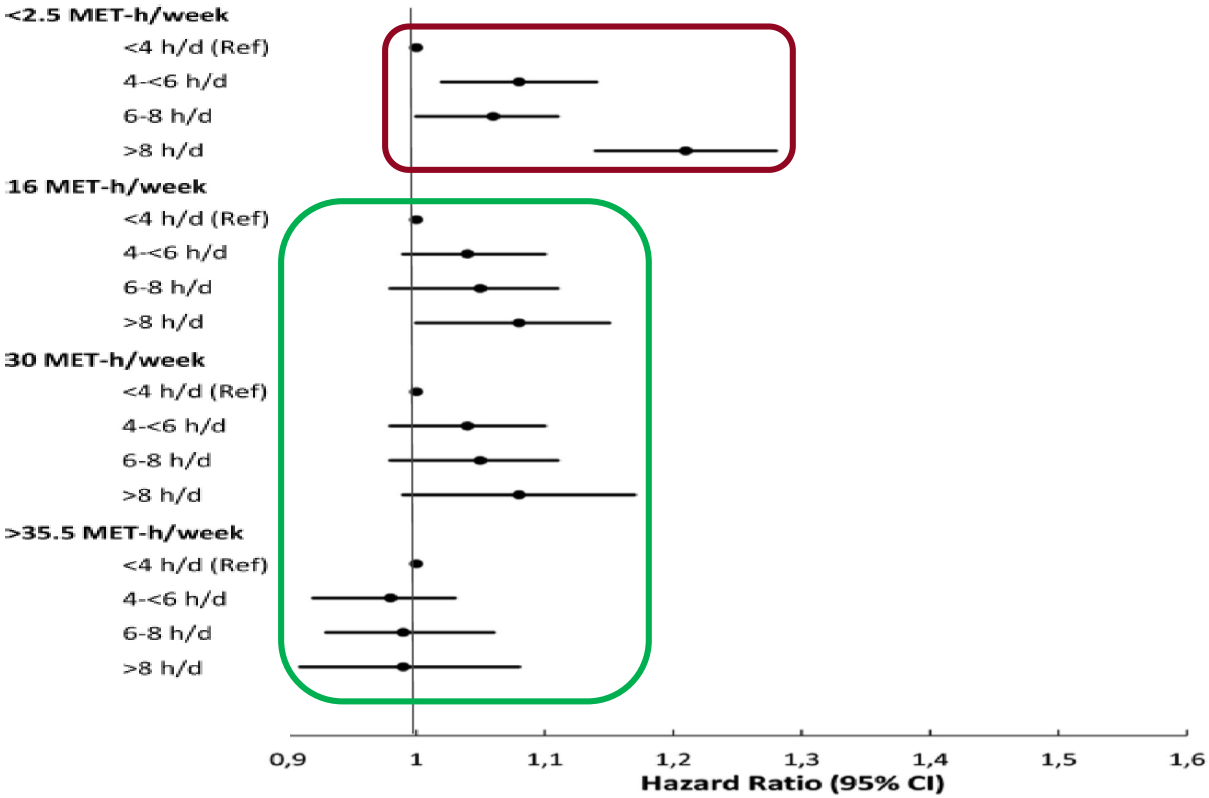
(Ekelund et al, Lancet 2016;388:1302-10)

Do the associations of sedentary behaviour with cardiovascular disease mortality and cancer mortality differ by physical activity level? A systematic review and harmonised meta-analysis of data from 850 060 participants



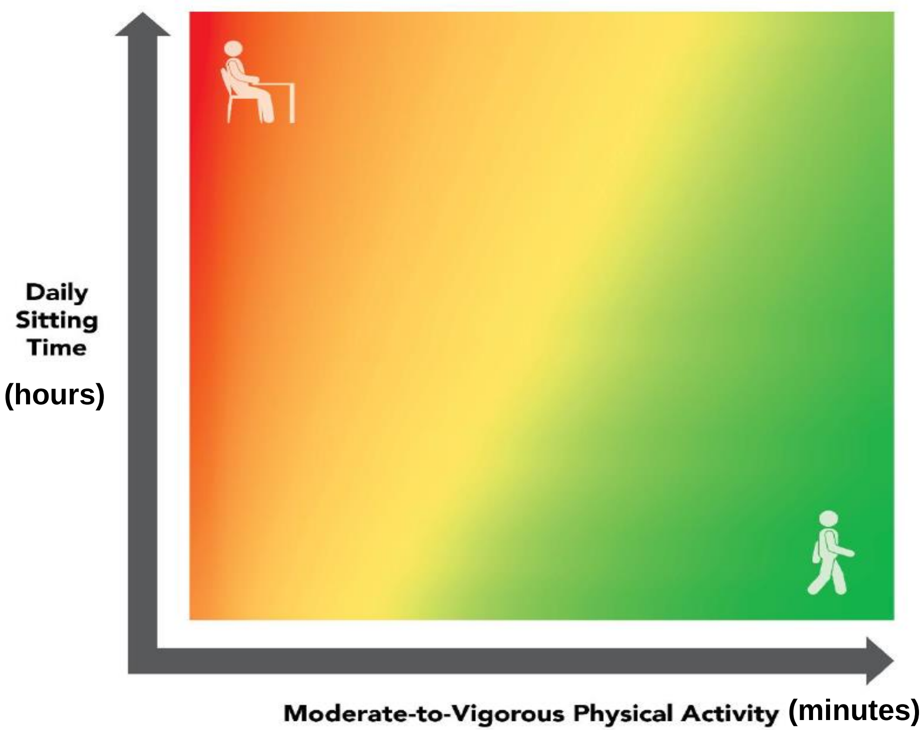
(Ekelund et al, BJSM 2018)

Physical Activity, Sitting and cancer mortality (N=777 696; 30851 deaths)



(Ekelund et al, BJSM 2018)

Sitting and activity interact and can be combined differently to reduce the risk!



Risk of all-cause mortality decreases as one moves from red to green.

(2018 Physical Activity Guidelines Advisory Committee scientific Report, Washington DC, U.S. Department of Health and Human Services, 2018)

Take home message

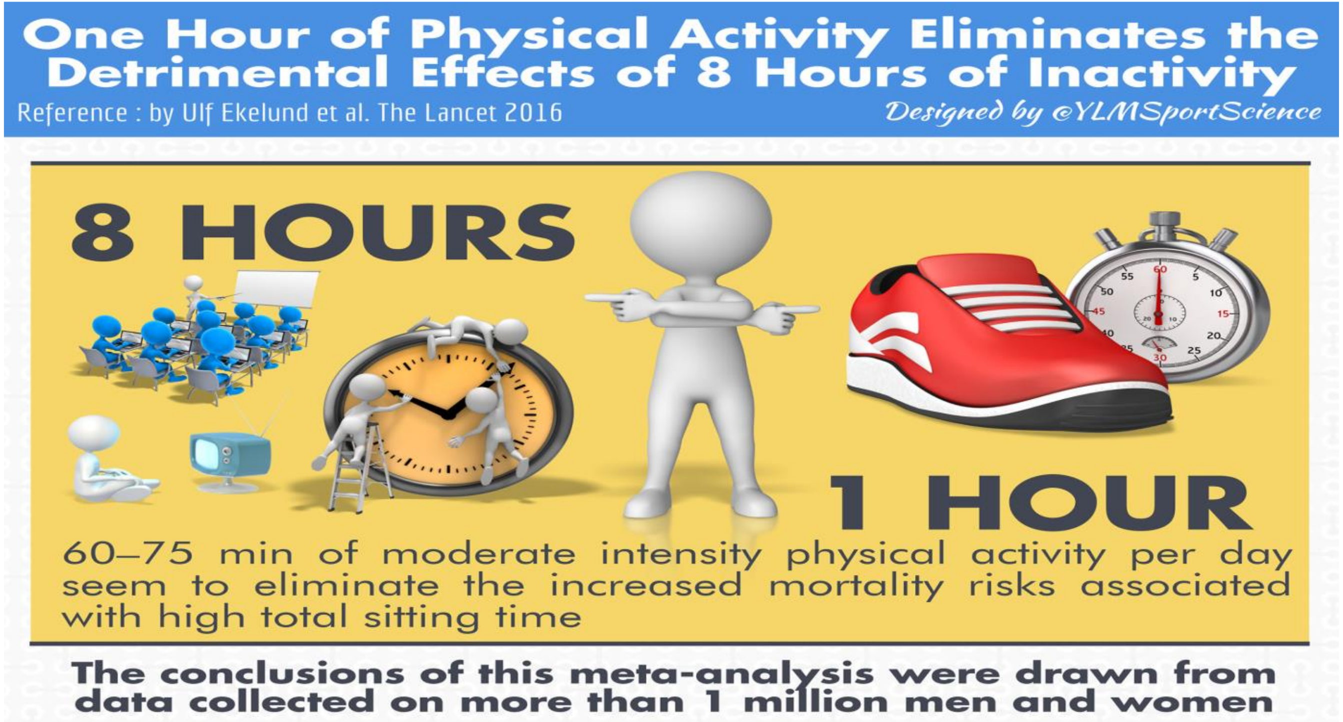
Low levels of physical activity may contribute but are likely not the main driver of the 'obesity epidemic'

The health benefits from physical activity are well established, undisputable and may eliminate the adverse effects of prolonged sitting

Therefore, a stronger emphasis on promoting physical activity for health rather than focusing on body weight may have important public health implications

The challenge is to shift the focus from body weight to lifestyle behaviour change and look beyond the weight scale in individuals and populations

THANK YOU FOR THE ATTENTION



(Infographic BJSM 2018)

The solution
(or more correctly – maybe a part of the solution)

Changing the environment?

Physical activity in relation to urban environments in 14 cities worldwide: a cross-sectional study

IPEN STUDY

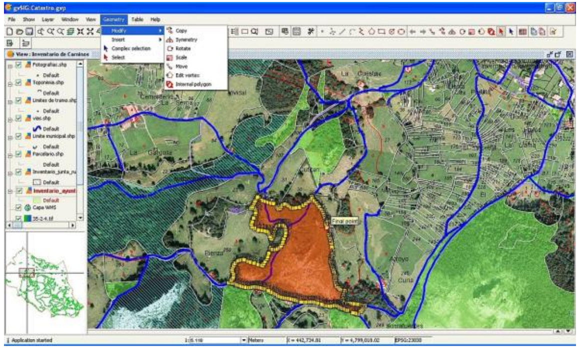
N=6822

18-66 Years

14 cities, 5 continents, 10 countries (HIC + MIC)

Accelerometry

Geographic Information System



(Sallis et al, Lancet 2016)

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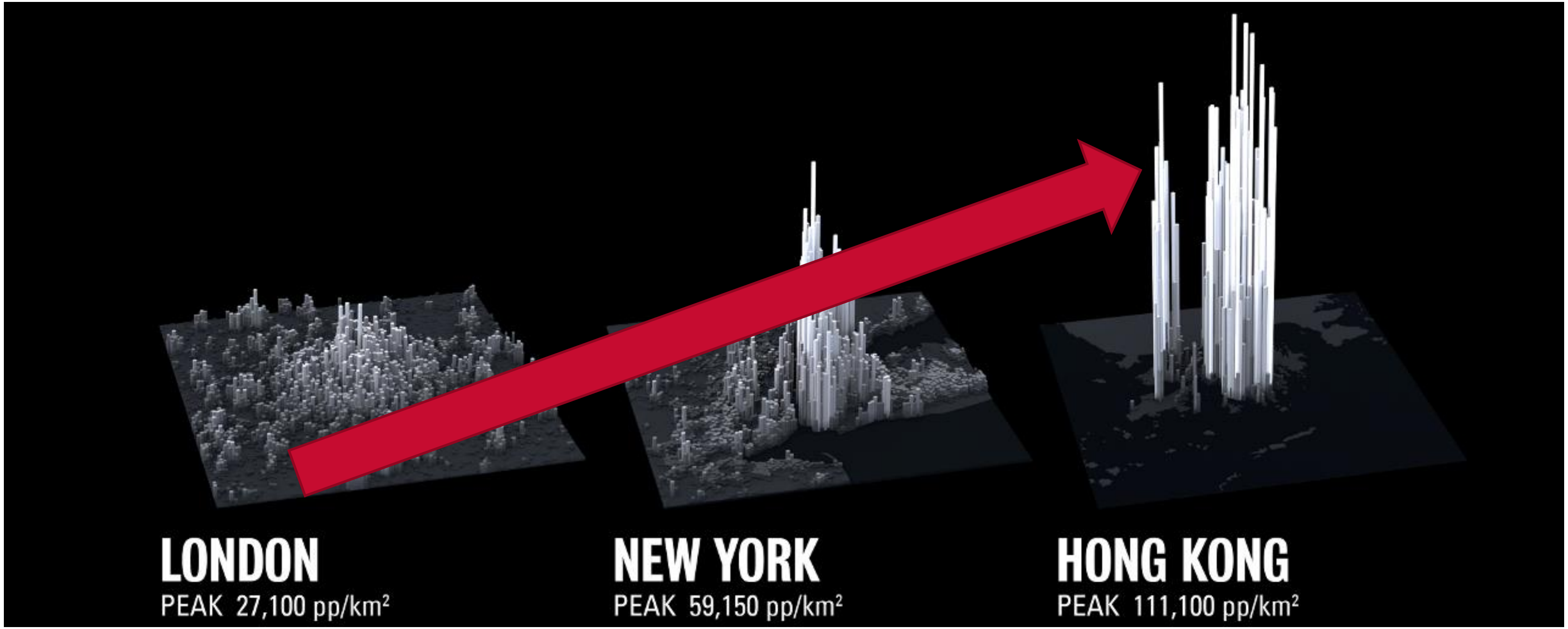
NORWEGIAN SCHOOL OF SPORT SCIENCES

Net residental density



(Sallis et al, Lancet 2016)

Intersection density

Source: Allan B. Jacobs, *Great Streets*, MIT Press, Cambridge, MA, 1993, pp. 221, 225, 249. Reprinted in Reid Ewing, *Pedestrian and Transit-Friendly Design: A Primer for Smart Growth*, Smart Growth Network, August 1999, p. 4. <http://www.epa.gov/dced/pdf/ptfd_primer.pdf>

(Sallis et al, Lancet 2016)

Public Transport density

(Sallis et al, Lancet 2016)

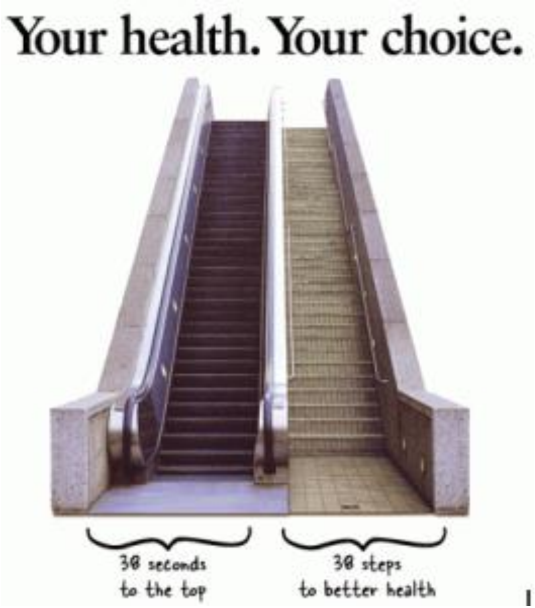
Number of parks

The difference in PA between participants living in the most and the least activity friendy environments ranged from 68 min/w to 89 min/w

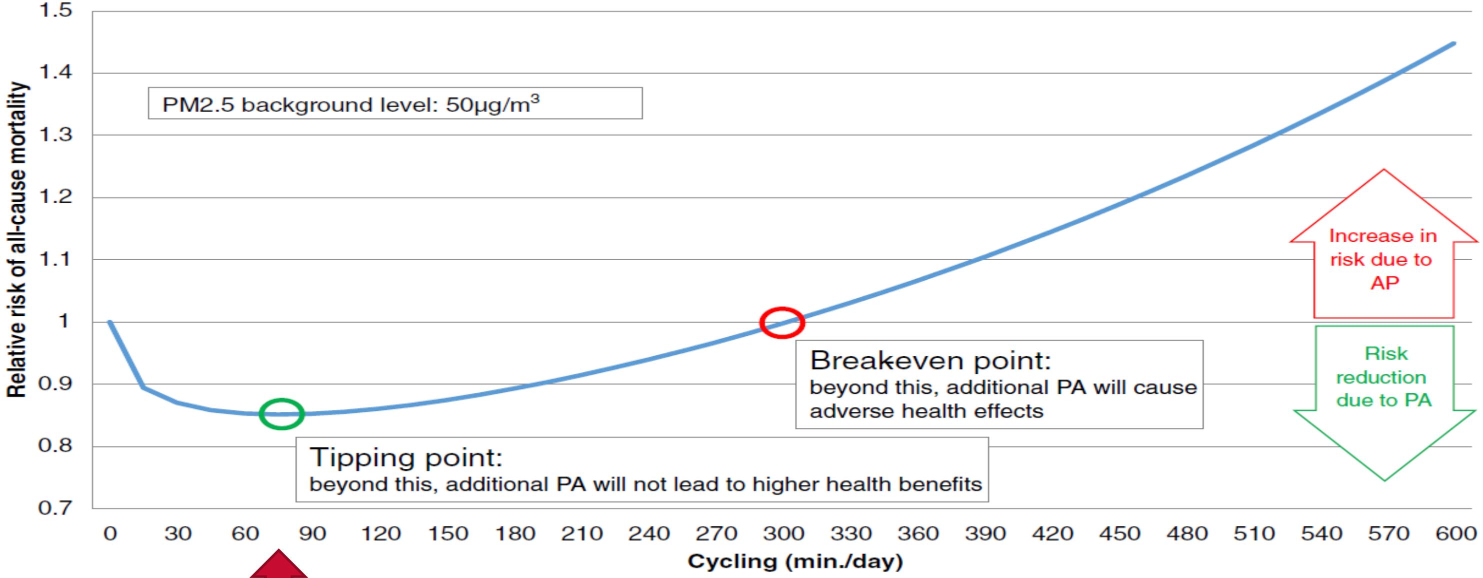
(Sallis et al, Lancet 2016)

Ugrently needed: Environmental changes

Required: Brave political decisions



The Facts: Can air pollution negate the health benefits of cycling and walking?

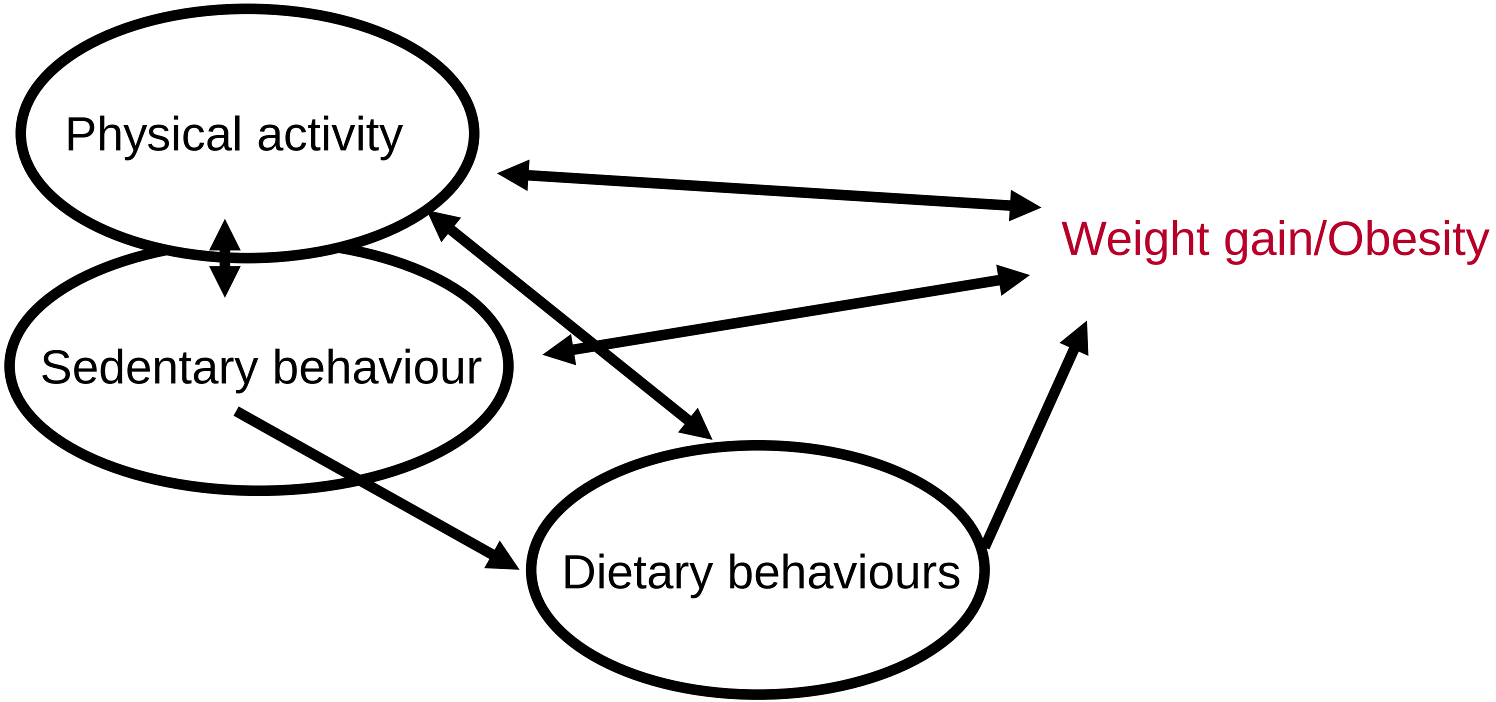


Less than 1% of cities

PA benefits from cycling outweighted the harm caused by air polution in all but the most extreme cases

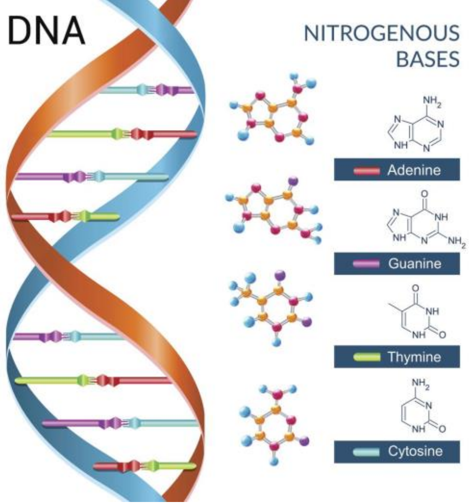
(Tainio et al, Prev Med 2016)

Bi-directional associations?



(Back of an envelope but informed by data)

What about genetics?

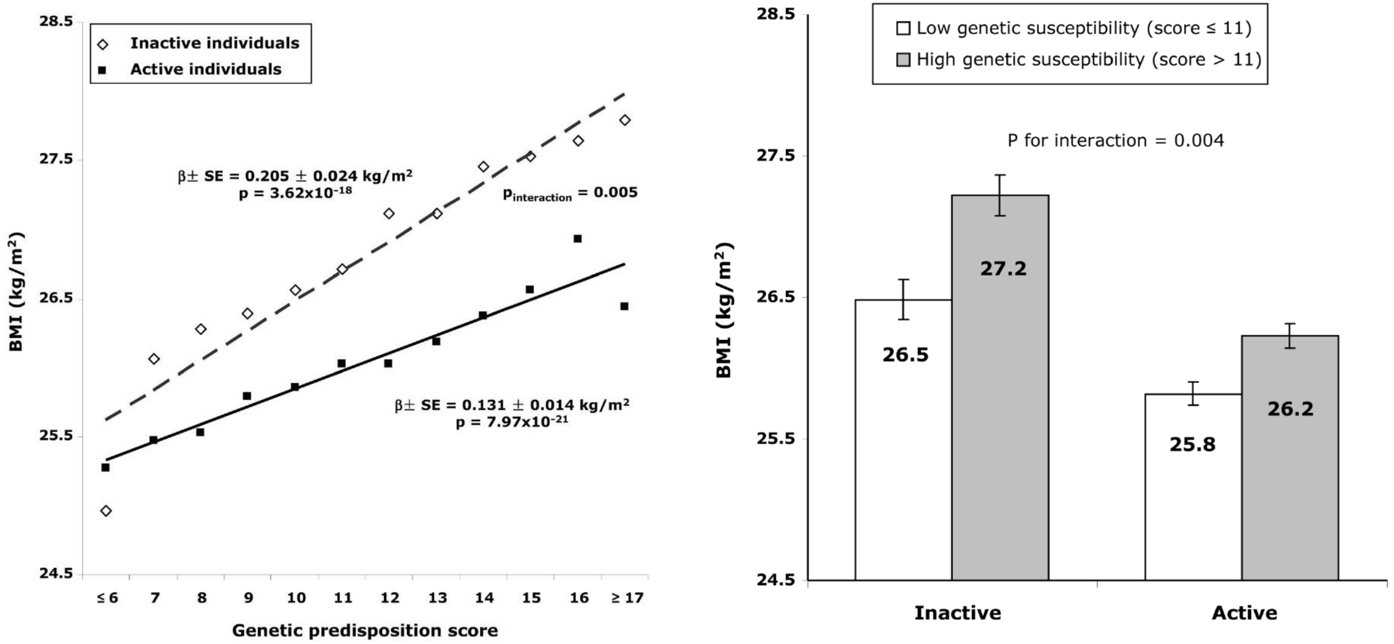


Genetic studies of body mass index yield new insights for obesity biology

Obesity is heritable and predisposes to many diseases. To understand the genetic basis of obesity better, here we conduct a genome-wide association study and Metabochip meta-analysis of body mass index (BMI), a measure commonly used to define obesity and assess adiposity, in up to 339,224 individuals. This analysis identifies 97 BMI-associated loci ($P < 5 \times 10^{-8}$), 56 of which are novel. Five loci demonstrate clear evidence of several independent association signals, and many loci have significant effects on other metabolic phenotypes. The 97 loci account for ~2.7% of BMI variation, and genome-wide estimates suggest that common variation accounts for >20% of BMI variation. Pathway analyses provide strong support for a role of the central nervous system in obesity susceptibility and implicate new genes and pathways, including those related to synaptic function, glutamate signalling, insulin secretion/action, energy metabolism, lipid biology and adipogenesis.

(Locke et al, Nature 2015)

Physical Activity Attenuates the Genetic Predisposition to Obesity in 20,000 Men and Women from EPIC-Norfolk Prospective Population Study



Being physically active is associated with a 40% reduction in the genetic predisposition to common obesity

(Li et al, *PLOS Med*, 2010)

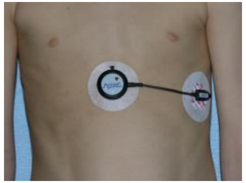
Interpretation of the Direction of Association

- The use of an imprecise measure of an exposure variable (PA) will tend to *underestimate* its relationship with an outcome variable (**regression dilution**)

- The use of an imprecise outcome variable (PA) *increase the uncertainty* in the estimate of the effect size (wider confidence intervals) and does not result in systematic underestimation of the association

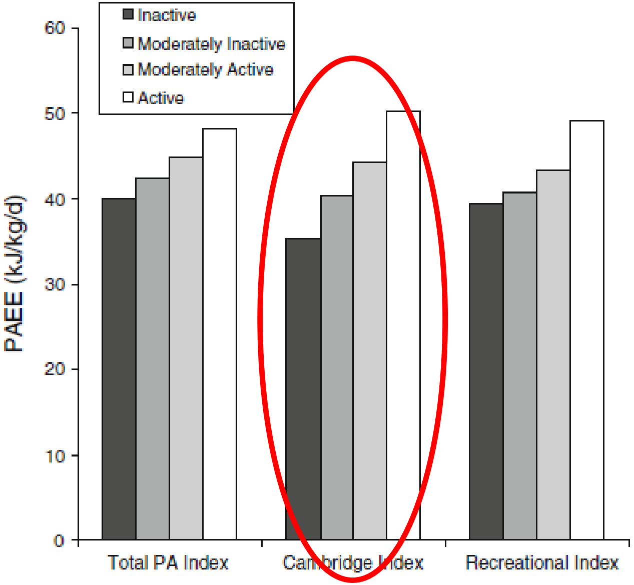
- **Be cautious when interpreting associations when exposures and outcomes are measured with differnt degree of precision**

Methods; Assessment of Physical Activity



N=1941 from 10 countries
Combined movement + HR
4 category PA index (”Cambridge Index”)

Work activity	Leisure time physical activity (Duration of sport and cycling in hrs/wk)			
	No	≤3.5	>3.5 and ≤7.0	> 7.0
Sedentary	Inactive	Moderately inactive	Moderately active	Active
Standing	Moderately inactive	Moderately active	Active	Active
Manual	Moderately active	Active	Active	Active
Heavy manual	Active	Active	Active	Active

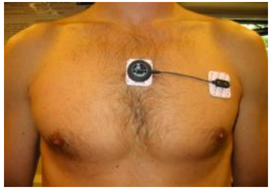


One-level difference in the Cambridge index equals approximately 90 and 110 KCal in men and women, respectively (20 min of walking @ 5.5 km/h)

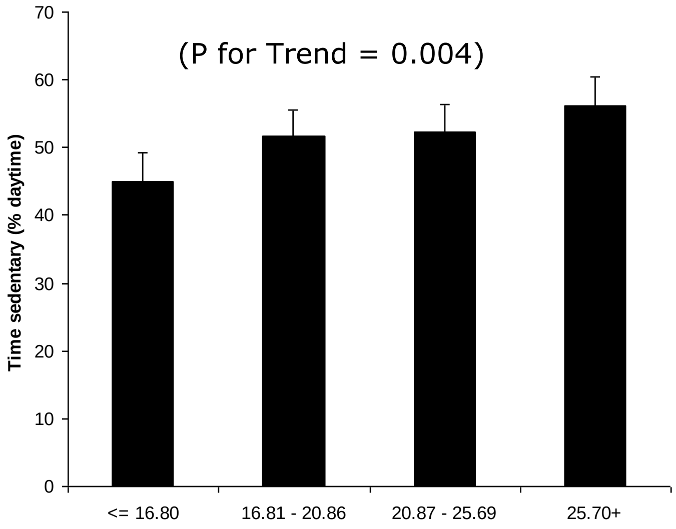
(InterAct Consortium, *Euro J Epidemiol*, 2012)

Direction of association – reverse causality?

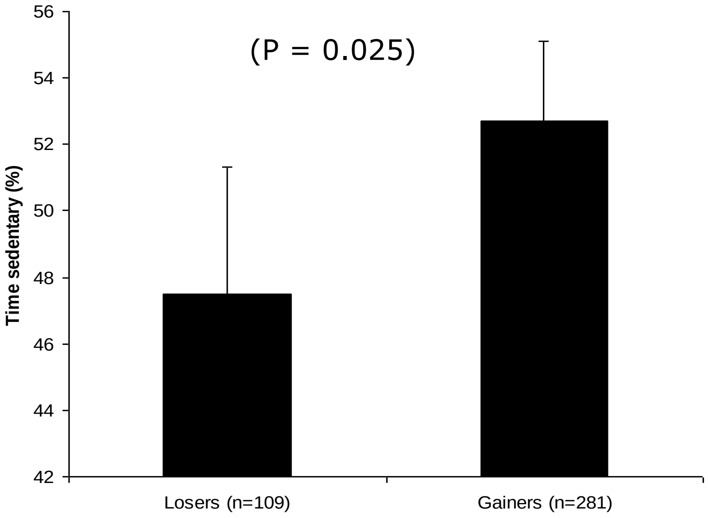
Time spent being sedentary and weight gain in healthy adults: reverse or bidirectional causality?[1–3]



Time spent sedentary at follow up stratified by quartiles of FM at baseline.



Time spent sedentary at follow up stratified by fat mass losers and gainers between baseline and follow up



(Ekelund et al, *AJCN* 2008;88:612-17)

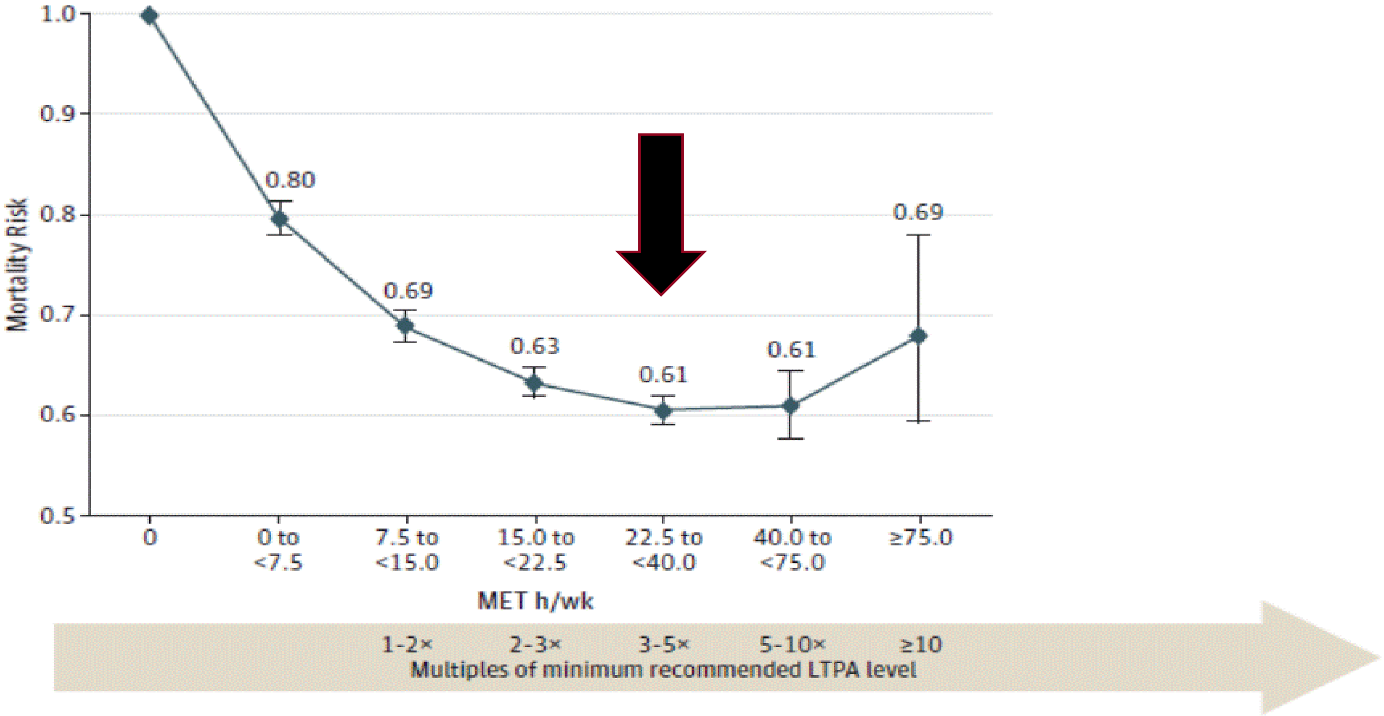
Sedentary Time, Physical Activity, and Adiposity: Cross-sectional and Longitudinal Associations in CARDIA

	Sedentary time (per hour/day)		MVPA (per 30 minutes/week)	
Variable	**β**	***p*-value**	**β**	***p*-value**
Cross-sectional				
BMI				
Total	**0.20**	**0.047**	**−0.15**	**<0.001**
Prolonged	**0.23**	**0.013**	**−0.18**	**<0.001**
WC, cm				
Total	**0.67**	**0.003**	**−0.46**	**<0.001**
Prolonged	**0.73**	**<0.001**	**−0.47**	**<0.001**
5-year change				
BMI				
Total	0.065	0.108	0.004	0.750
Prolonged	**0.077**	**0.033**	0.003	0.811
WC, cm				
Total	0.151	0.130	0.006	0.851
Prolonged	**0.198**	**0.028**	0.004	0.898

	Sufficient MVPA[a] (*n*=417)		Insufficient MVPA[a] (*n*=1,409)	
Variable	**β**	***p*-value**	**β**	***p*-value**
Cross-sectional				
BMI				
Total	−0.05	0.777	**0.25**	**0.042**
Prolonged	0.03	0.822	**0.25**	**0.019**
WC, cm				
Total	−0.22	0.577	**0.86**	**0.001**
Prolonged	0.12	0.736	**0.84**	**<0.001**
5-year change				
BMI				
Total	0.032	0.666	0.074	0.116
Prolonged	0.039	0.553	**0.087**	**0.042**
WC, cm				
Total	0.338	0.081	0.104	0.372
Prolonged	0.260	0.134	0.180	0.086

(Gibbs et al, Am J Prev Med, 2017)

Public Health Relevance



(Arem et al, *JAMA Int Med*, 2015)