



NORWEGIAN SCHOOL OF SPORT SCIENCES

Physical Activity and Prevention of Weight Gain and Obesity in Adults

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An Epidemiological Perspective

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The association between diet and physical activity and subsequent excess weight gain and obesity assessed at 5 years of age or older: a systematic review of the epidemiological evidence



*Epidemiological evidence shows that physical activity, in general, **is not associated** with subsequent excess weight gain and obesity.*

*Most of the studies reporting total physical activity had either **no effect or a small negative association** with subsequent excess weight gain*

Outline – Questions

- Does higher levels of physical activity prevent weight gain over time?
- Does higher levels of physical activity prevent development of obesity over time?
- Does the association between activity and weight gain differ pending on baseline weight status?
- Is change in activity associated with change in body weight?
- Does weight status predict physical inactivity over time?

Does activity prevent weight gain?

Baseline Physical Activity



Follow up Body Weight

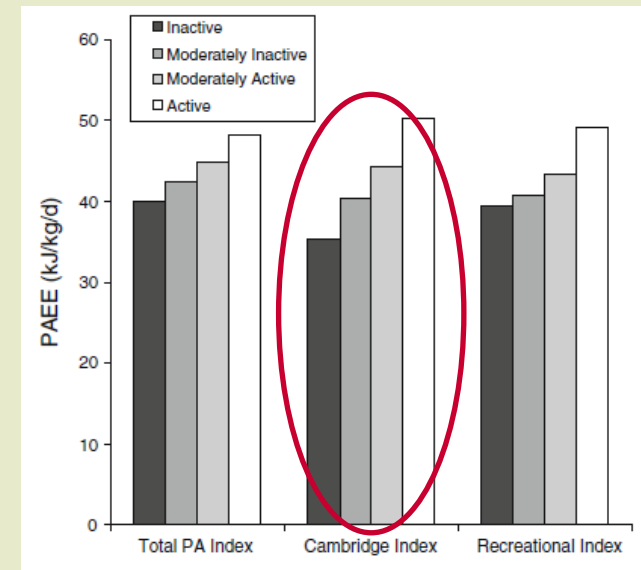


This model determines the direction of association

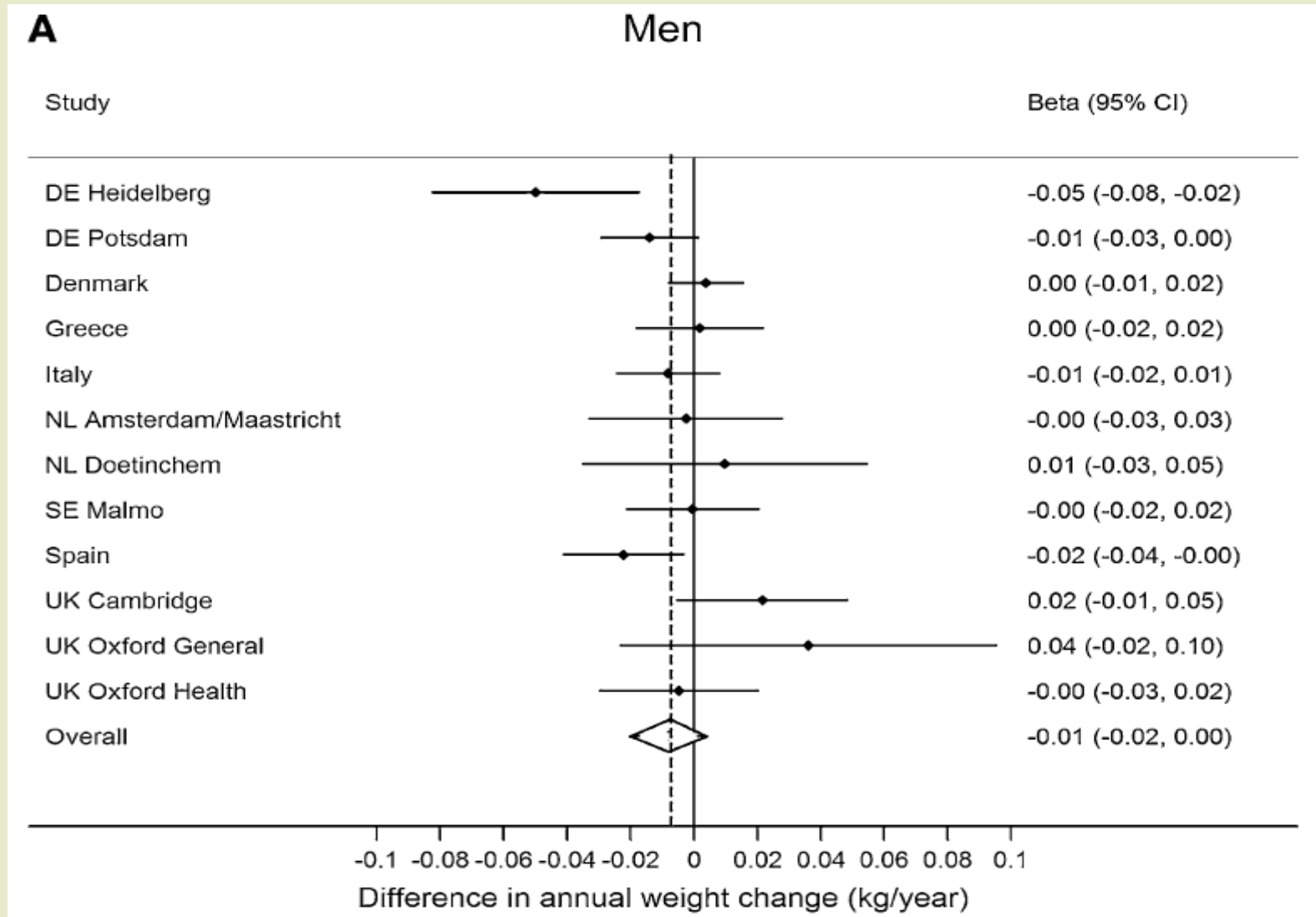
Physical activity and gain in abdominal adiposity and body weight: prospective cohort study in 288,498 men and women¹⁻⁴

- 5.1 yrs follow-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

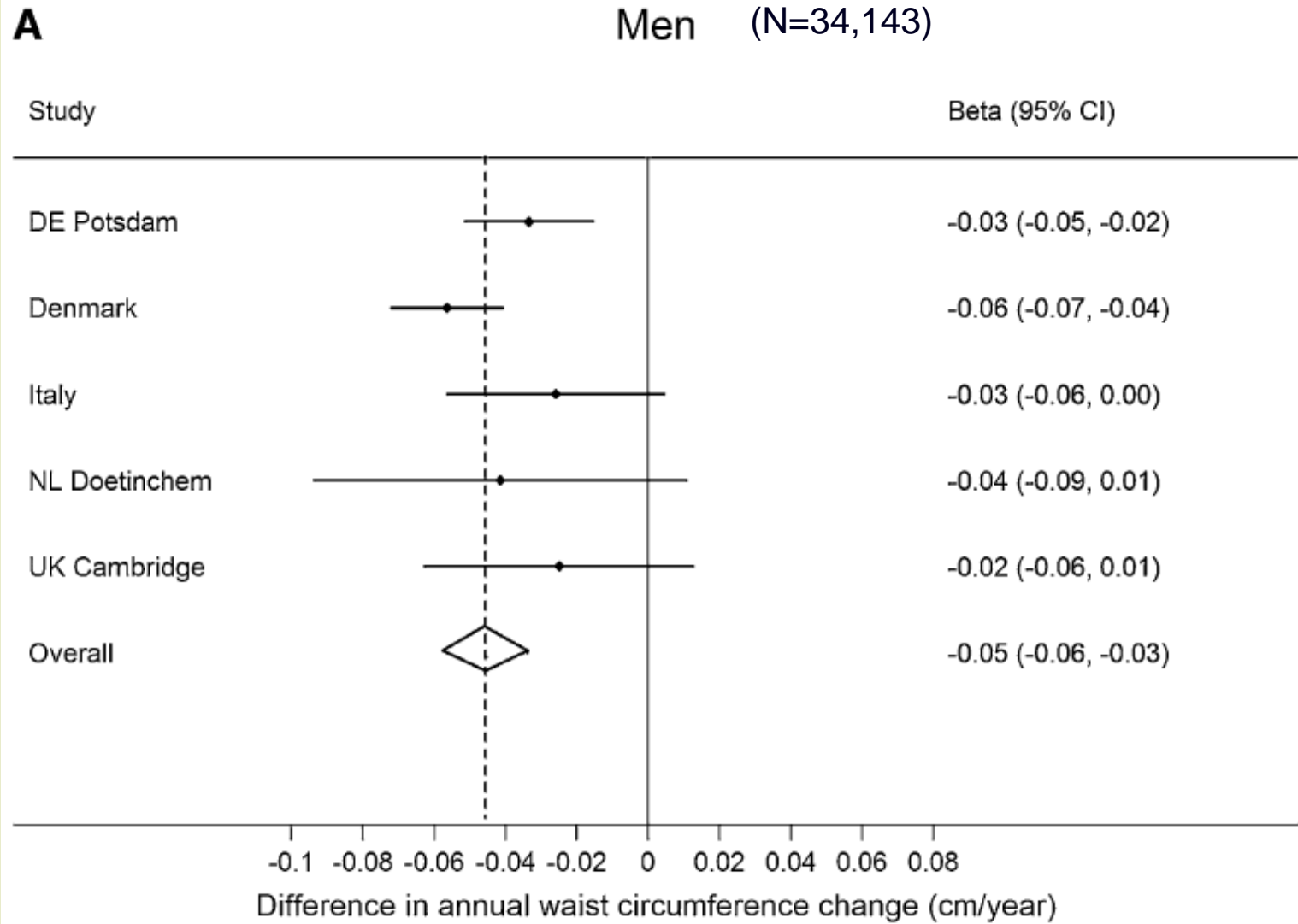
| | Leisure time physical activity (Duration of sport and cycling in hrs/wk) | | | |
|---------------|---|---------------------|-------------------|--------|
| | No | ≤3.5 | >3.5 and ≤7.0 | >7.0 |
| Work activity | | | | |
| Sedentary | Inactive | Moderately inactive | Moderately active | Active |
|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



Physical activity and gain in abdominal adiposity and body weight: prospective cohort study in 288,498 men and women¹⁻⁴



Physical activity and gain in abdominal adiposity and body weight: prospective cohort study in 288,498 men and women¹⁻⁴

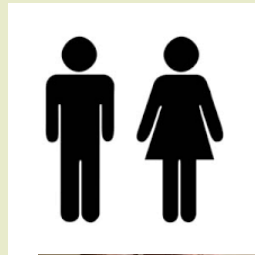
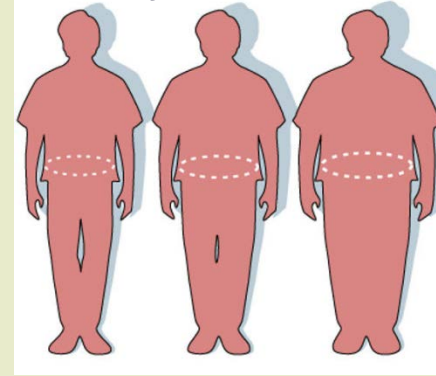


Does activity prevent development of obesity?

Baseline activity in those who are non-obese

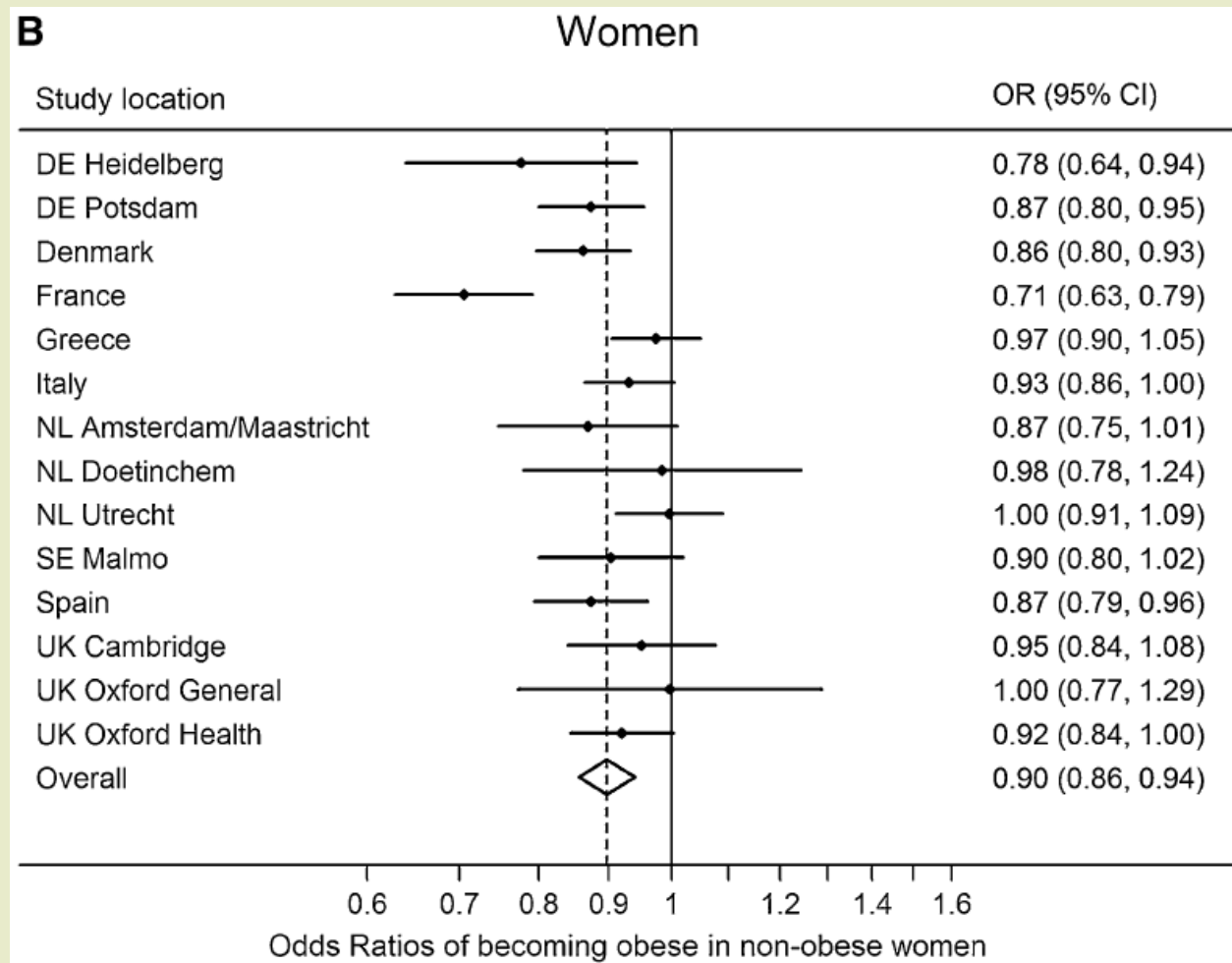


Obesity at follow-up



Physical activity and gain in abdominal adiposity and body weight: prospective cohort study in 288,498 men and women¹⁻⁴

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



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

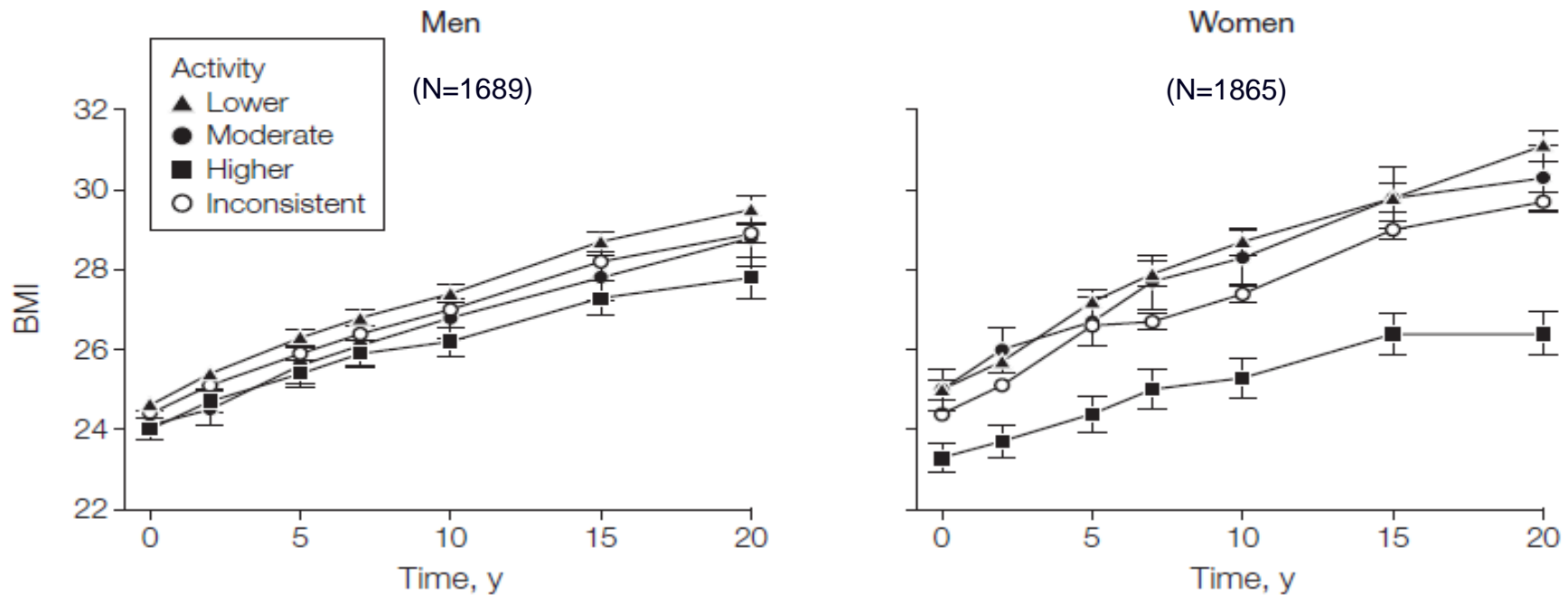
Women's Health Study (N=19,003) followed for 11.6 years; 7865 become OW or Obese

| Amount of weekly physical activity | Cases | Crude incidence rate (cases/10,000 person years) | Age-adjusted | Multivariable model ^a | Multivariable model + BMI ^b |
|------------------------------------|-------|--|------------------|----------------------------------|--|
| <i>Moderate physical activity</i> | | | | | |
| 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) |
| <i>P</i> for trend | | | 0.2 | 0.07 | 0.3 |
| <i>Vigorous physical activity</i> | | | | | |
| 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) |
| <i>P</i> for trend | | | <0.0001 | <0.0001 | 0.3 |

Vigorous intensity associated with lower risk of becoming overweight/obese

Maintaining a High Physical Activity Level Over 20 Years and Weight Gain

Figure. BMI at Each CARDIA Visit by Habitual Activity Category



BMI increased by 0.15 units / year in high active
and by 0.20 units / year in low active

BMI increased by 0.17 units / year in high active
and by 0.30 units / year in low active

Conclusion Maintaining high activity levels through young adulthood may lessen weight gain as young adults transition to middle age, particularly in women.

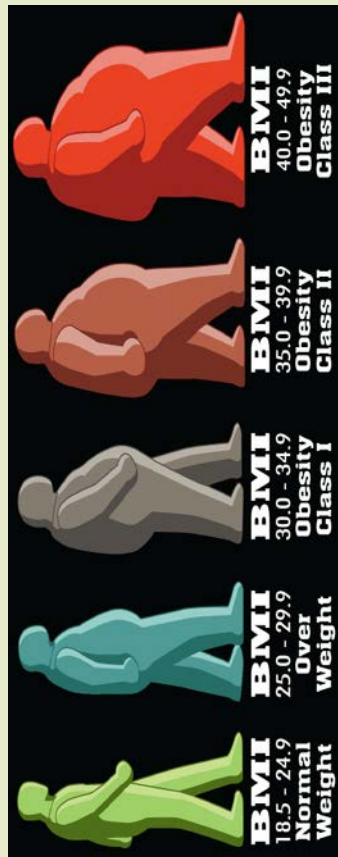
All groups gained weight

11-12 % remained in the HIGH PA group over 20 years

(Hankinson et al, JAMA 2010)

Different associations due to baseline weight / Obesity Status?

Stratification and test for interaction (PA x BMI)



Baseline Activity



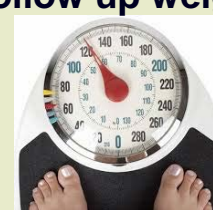
Follow up weight



Baseline Activity



Follow up weight



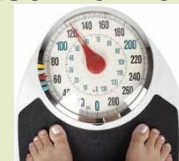
Baseline Activity



Follow up weight



Baseline Weight



Physical Activity and Weight Gain Prevention

Womens Health Study (N=34,079) – Mean weight gain = 2.6 kg / 3 years

Table 2. Mean (SD) Differences in Weight Over Any 3-Year Period by Physical Activity Level, Women's Health Study, 1992-2007^a

| Group | No. of Women ^b | Physical Activity, MET Hours per Week | | | P Value for Trend | P Value for Interaction |
|-------------------------------|---------------------------|---------------------------------------|--------------|---------------|-------------------|-------------------------|
| | | <7.5 | 7.5 to <21 | ≥21 | | |
| All women | | | | | | |
| Analytical model ^c | | | | | | |
| 1 | | 0.15 (0.04) | 0.12 (0.04) | 0 [Reference] | <.001 | |
| 2 | | 0.12 (0.04) | 0.11 (0.04) | 0 [Reference] | <.001 | |
| BMI | | | | | | |
| <25.0 | 17 475 | 0.21 (0.04) | 0.14 (0.04) | 0 [Reference] | <.001 | <.001 |
| 25-29.9 | 10 516 | -0.04 (0.06) | -0.04 (0.06) | 0 [Reference] | .56 | |
| ≥30.0 | 6088 | 0.16 (0.14) | 0.13 (0.16) | 0 [Reference] | .50 | |

Conclusions Among women consuming a usual diet, physical activity was associated with less weight gain only among women whose BMI was lower than 25. Women successful in maintaining normal weight and gaining fewer than 2.3 kg over 13 years averaged approximately 60 minutes a day of moderate-intensity activity throughout the study.

Physical activity and gain in abdominal adiposity and body weight: prospective cohort study in 288,498 men and women¹⁻⁴

Mean weight gain = 0.5 kg in men and 1 kg in women

Physical activity and annual weight gain stratified by baseline BMI

| | β Coefficient (95% CI) | <i>P</i> for linear trend |
|------------------------------------|------------------------------|---------------------------|
| Men (<i>n</i> = 84,511) | | |
| <50 y of age | | |
| Normal weight (<i>n</i> = 10,527) | -0.025 (-0.042, -0.007) | 0.006 |
| Overweight (<i>n</i> = 13,756) | -0.025 (-0.058, 0.007) | 0.12 |
| Obese (<i>n</i> = 4217) | -0.024 (-0.064, 0.017) | 0.25 |
| All (<i>n</i> = 28,500) | -0.029 (-0.041, -0.016) | <0.001 |
| Women (<i>n</i> = 203,987) | | |
| <50 y of age | | |
| Normal weight (<i>n</i> = 56,832) | -0.024 (-0.032, -0.016) | <0.001 |
| Overweight (<i>n</i> = 19,642) | -0.016 (-0.034, 0.0028) | 0.097 |
| Obese (<i>n</i> = 7835) | 0.015 (-0.022, 0.053) | 0.42 |
| All (<i>n</i> = 84,309) | -0.015 (-0.029, -0.0007) | 0.040 |

An inverse association between physical activity and weight gain was observed in men and women (< 50 years) who were normal weight at baseline

Change in activity associated with change in body weight?



Exposure and outcome measured at least twice

Associations between changes in variables (follow up minus baseline)

This model cannot determine the direction of association

Physical activity patterns and prevention of weight gain in premenopausal women

Nurses Health Study II (N=46,754)

Data are OR for gaining >5% of baseline weight with change in PA as exposure

| <i>Activity (min d^{-1}) and inactivity (hours per week) patterns</i> | <i>n</i> | <i>MV-OR (95%CI)^a</i> |
|---|----------|----------------------------------|
| <i>(a) Total discretionary activity pattern (min d^{-1})</i> | | |
| Lo89lo97 ($< 30 \text{ min d}^{-1}$ in 1989 and 1997) | 19 959 | 1.00 (Referent) |
| Hi89hi97 ($\geq 30 \text{ min d}^{-1}$ in 1989 and 1997) | 11 063 | 0.68 (0.64–0.73) |
| Lo89hi97 (increase) | 6922 | 0.64 (0.60–0.68) |
| Hi89lo97 (decrease) | 8810 | 1.12 (1.05–1.20) |

Sustained PA for >30 min / d is associated with lower odds of gaining > 5% of baseline body weight

Changes in Diet and Lifestyle and Long-Term Weight Gain in Women and Men

Results from 3 cohorts in men and women (N=120,877)

| Lifestyle Habit | Weight Change Every 4 Years (95% Confidence Interval) | | | |
|--|---|---------|--------------------------------|---------|
| | Age-Adjusted Change | P Value | Multivariable-Adjusted Change† | P Value |
| | lb | | lb | |
| Physical-activity change, median change in MET-hr/wk | | | | |
| Quintile 1: -16.3 | Reference | | Reference | |
| Quintile 2: -2.59 | -0.07 (-0.36 to 0.22) | 0.64 | -0.07 (-0.32 to 0.18) | 0.60 |
| Quintile 3: 1.59 | -0.85 (-1.11 to -0.59) | <0.001 | -0.81 (-1.02 to -0.60) | <0.001 |
| Quintile 4: 6.49 | -1.00 (-1.10 to -0.91) | <0.001 | -0.92 (-1.02 to -0.83) | <0.001 |
| Quintile 5: 23.2 | -1.86 (-2.31 to -1.41) | <0.001 | -1.76 (-2.14 to -1.38) | <0.001 |

”Absolute levels of PA rather than changes in these levels were not associated with weight change (data not shown)”

Does weight status predict physical inactivity?

Baseline Weight



Follow up Activity

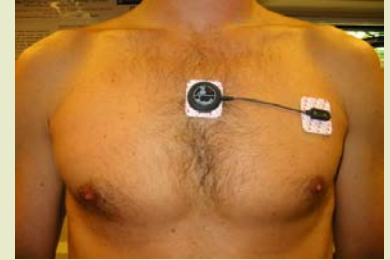


Baseline Activity



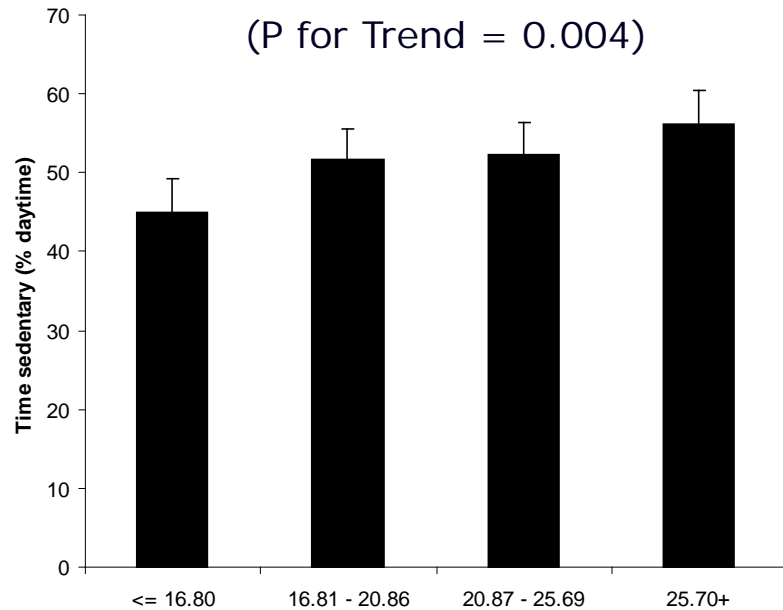
Reverse or bidirectional causality?

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

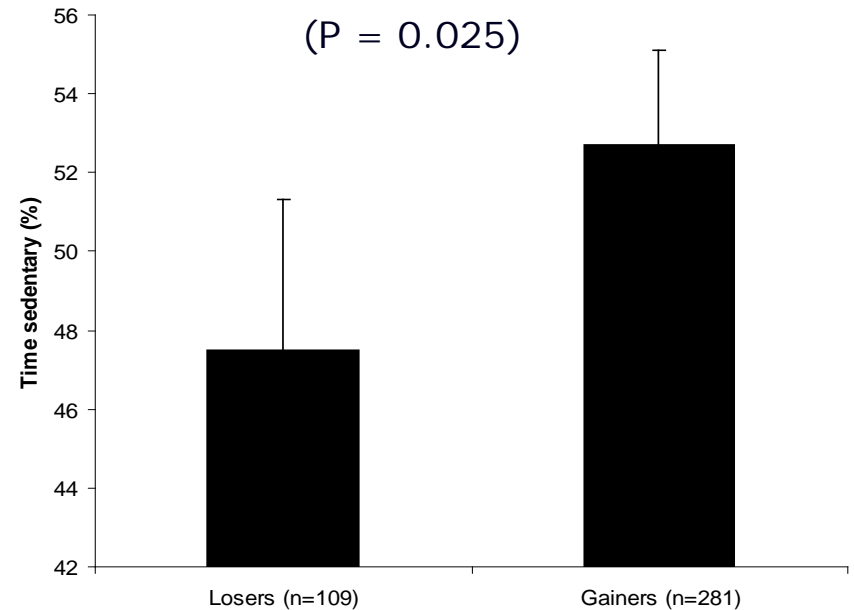


The MRC Ely Study (N=390)

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



Baseline FM predicts higher amounts of sedentary time

Rate of weight gain predicts change in physical activity levels: a longitudinal analysis of the EPIC-Norfolk cohort

| | N | OR (95% CI) |
|--|------|----------------------|
| <i>From baseline to 3-year follow-up</i> | 7597 | |
| Continuous weight change (kg per year) | 7597 | 1.042 (0.993; 1.091) |
| Lost > 0.5 kg per year | 1241 | 1.120 (0.951; 1.319) |
| Maintained weight (± 0.5 kg per year) | 2874 | 1.0 reference |
| Gained 0.5–2 kg per year | 2982 | 1.119 (0.985; 1.272) |
| Gained > 2 kg per year | 500 | 1.406 (1.113; 1.777) |
| <i>From baseline to 10-year follow-up</i> | 8987 | |
| Continuous weight change (kg per year) | 8987 | 1.107 (1.037; 1.183) |
| Lost > 0.5 kg per year | 1162 | 1.050 (0.899; 1.225) |
| Maintained weight (± 0.5 kg per year) | 5175 | 1.0 reference |
| Gained 0.5–2 kg per year | 2481 | 1.255 (1.113; 1.415) |
| Gained > 2 kg per year | 169 | 1.878 (1.304; 2.704) |

Weight gain (>0.5 kg / year) over 10 years is a significant determinant of physical inactivity independent of baseline weight, physical activity and other confounders

Summary

- The prospective association between physical activity and gain in body weight and BMI is weak – **measurement error?**
- High levels of physical activity and maintaining high levels of activity appears to reduce the risk of becoming obese over time – **limited to those who are normal-weight?**
- The association between physical activity and obesity is likely bi-directional – **reverse causation?**
- The amount and intensity of activity needed to maintain a healthy body weight (Normal BMI) throughout adulthood is unknown but likely substantial

Despite this, increasing population levels of physical activity is possibly the single 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}

| | Deaths | 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)

Take home message

Physical activity prevent weight in a small segment of the population who are normal weight and highly physically active

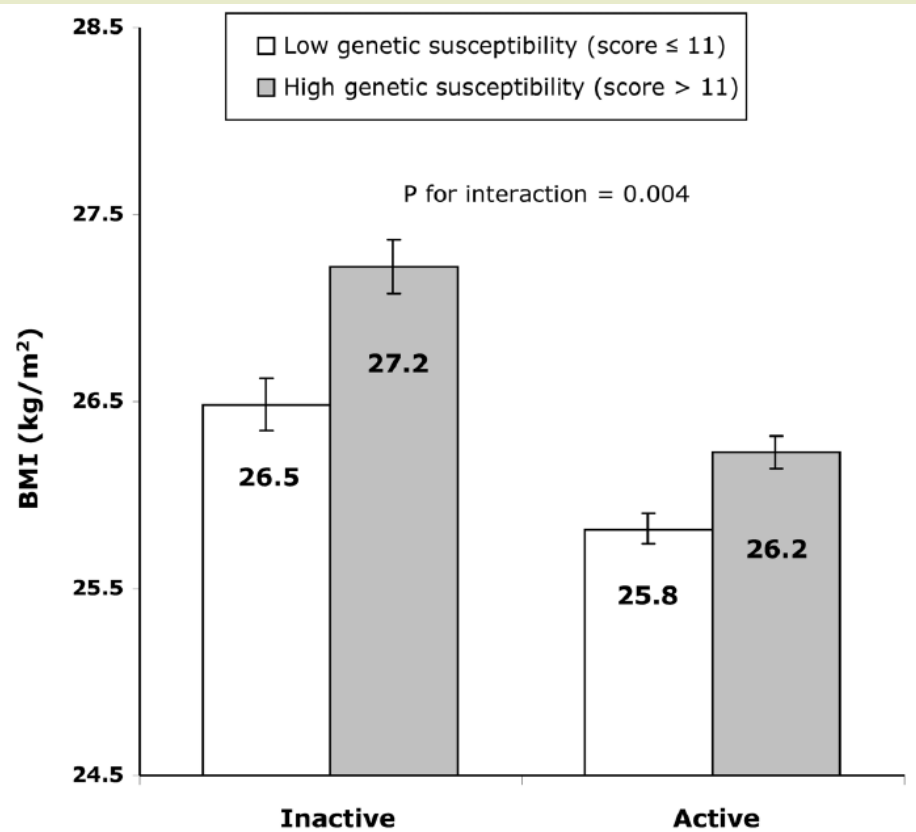
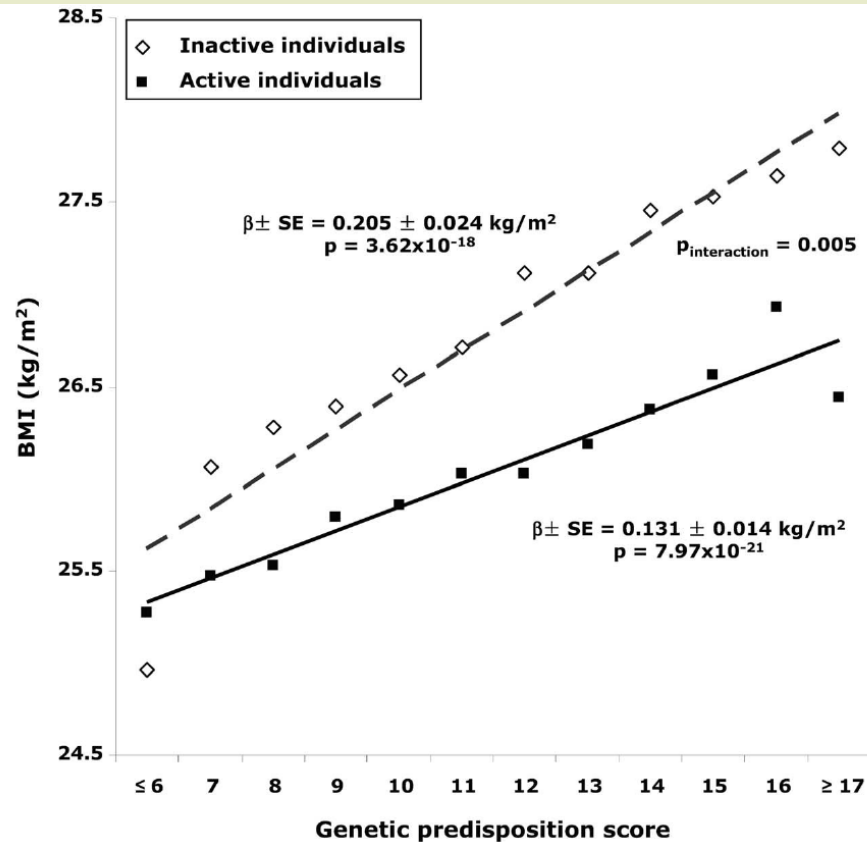
The health benefits from physical activity are well established and undisputable

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 loss to lifestyle behaviour change and look beyond the weight scale in individuals and populations



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



Living a physically active lifestyle is associated with 40% reduction in the genetic predisposition to obesity

High Sitting Time or Obesity: Which Came First? Bidirectional Association in a Longitudinal Study of 31,787 Australian Adults

Zeljko Pedisic^{1,2}, Anne Grunseit¹, Ding Ding¹, Josephine Y. Chau¹, Emily Banks^{3,4}, Emmanuel Stamatakis^{1,5,6,7}, Bin B. Jalaludin⁸ and Adrian E. Bauman¹

Objective: Evidence on the direction of the association between sitting time and obesity is limited. The prospective associations between baseline total sitting time and subsequent changes in body mass index (BMI), and baseline BMI and subsequent changes in sitting time were examined.

Methods: BMI, from self-reported height and weight, and a single-item measure of sitting time were ascertained at two time points (3.4 ± 0.96 years apart) in a prospective questionnaire-based cohort of 31,787 Australians aged 45–65 years without severe physical limitations.

Results: In a fully adjusted model, baseline obesity was associated with increased sitting time among all participants (adjusted odds ratio [aOR] = 1.20 [95% CI, 1.11-1.30]; $P < 0.001$) and in most subgroups. The association was significant among those who were sitting <4 hours/day (aOR = 1.24 [95% CI, 1.07-1.44]; $P = 0.004$) and 4–8 hours/day at baseline (aOR = 1.18 [95% CI, 1.06-1.32]; $P = 0.003$), but not in the high sitting groups ($P = 0.111$ and 0.188 for 8–11 and ≥ 11 sitting hours/day, respectively). Nonsignificant and inconsistent results were observed for the association between baseline sitting time and subsequent change in BMI.

Conclusions: Our findings support the hypothesis that obesity may lead to a subsequent increase in total sitting time, but the association in the other direction is unclear.

Exploring Causality between TV Viewing and Weight Change in Young and Middle-Aged Adults. The Cardiovascular Risk in Young Finns Study

Harri Helajärvi^{1*}, Tom Rosenström², Katja Pahkala^{1,3}, Mika Kähönen⁴, Terho Lehtimäki⁵, Olli J. Heinonen¹, Mervi Oikonen³, Tuija Tammelin⁶, Jorma S. A. Viikari⁷, Olli T. Raitakari^{3,8}

Background: Television viewing time (TV time) is associated with increased weight and obesity, but it is unclear whether this relation is causal.

Methods and Results: We evaluated changes in TV time, waist circumference (waist) and body mass index (BMI) in participants of the population-based Cardiovascular Risk in Young Finns study (761 women, 626 men aged 33–50 years in 2011). Waist and BMI were measured, and TV time was self-reported in 2001, 2007, and 2011. Changes in waist and BMI between 2001 and 2011 were studied a) for the whole group, b) in groups with constantly low (≤ 1 h/d), moderate (1–3 h/d), or high (≥ 3 h/d) TV time, and c) in groups with ≥ 1 hour in-/decrease in daily TV time between 2001 and 2011. BMIs in 1986 were also evaluated. We explored the causal relationship of TV time with waist and BMI by classical temporality criterion and recently introduced causal-discovery algorithms (pairwise causality measures). Both methods supported the hypothesis that TV time is causative to weight gain, and no evidence was found for reverse or bidirectional causality. Constantly low TV time was associated with less pronounced increase in waist and BMI, and waist and BMI increase was lower with decreased TV time ($P < 0.05$). The increase in waist and BMI was at least 2-fold in the high TV time group compared to the low TV time group ($P < 0.05$). Adjustment for age, sex, BMI/waist in 2001, physical activity, energy intake, or smoking did not change the results.

Conclusions: In young and middle-aged adults, constantly high TV time is temporally antecedent to BMI and waist increase.