# Supplemental Online Content

This supplemental material has been provided by the authors to give readers additional information about their work.

**eMethods. Measurement of weight and height**

In the 1st and 2nd WHII evaluations, the participants wore only underwear for their weight measurement, which was to the nearest 0.1 kg on Soehnle electronic scales. For height measurements, to the nearest 1 mm using a stadiometer, the participants had bare feet and stood erect with their heads in the Frankfort plane. The repeatability of the weight and height measurements over one month (that is, between participant variability/total [between+within participant] variability), taken from 306 participants, was 0.99. After the first and second examination (1985-1988 and 1991-1993), assessment of BMI was repeated four times (1997–1999, 2002–2004, 2007–2009 and 2012–2013).

In the HBS, height and weight were directly measured at 1st and 2nd evaluation, but self-reported in later follow-ups in 2000, 2002/2003, 2007, and 2010/2011. In 2002/03 a random subgroup of 472 participants was clinically examined, and we found a strong correlation between reported and measured weight (Spearman correlation r = 0.93, P< 0.001). In FPS, both height and weight were self-reported.

We defined healthy weight as BMI less than 25 kg/m$^2$ and overweight as BMI $\geq$25 kg/m$^2$. Using weight and height measurements from the 1st and 2nd evaluation, we categorized participants into four groups: 1) Healthy BMI at both evaluations, 2) Overweight at the 1st evaluation and healthy BMI at the 2nd, 3) Healthy BMI at the 1st evaluation and overweight at the 2nd, and 4) Overweight at both evaluations.

In FPS, a larger sample size allowed a definition of weight groups based on three consecutive surveys on self-reported weight and height from surveys in 2000–2002, 2004–2005, 2008–2009 and 2011–2013: persistent healthy weight (healthy BMI in all three consecutive surveys), sustained weight loss (overweight in the first survey, healthy BMI in two subsequent surveys), weight gain (healthy BMI in the first survey, overweight in two subsequent surveys), and persistent overweight (overweight in all three surveys).

**eTable 1. Disease criteria for the 2ⁿᵈ clinical evaluation in the Helsinki Businessmen Study**

_____

1. Treated, secondary or severe hypertension (blood pressure ≥200 mmHg systolic or ≥ 115 mmHg diastolic

2. Cardiovascular diseases:

- history of myocardial infarction or

- typical angina pectoris

- defined ECG findings related to coronary artery disease, arrhythmias or conduction defects

- cardiomyopathies

- heart valve diseases

- heart failure

3. Cerebrovascular diseases

- history of stroke

- neurologic defects

4. Renal diseases

5. Metabolic diseases

    - medical treatment for diabetes

    - fasting blood glucose ≥10 mmol/L

6. Cancer

7. Psychiatric diseases

    - psychoses

    - alcoholism

_____

**eTable 2. Number (%) of missing values in primary analysis**

|  | Whitehall | HBS |
|---|---|---|
| **1st Evaluation** |  |  |
| Age | 0 (0.0) | 0 (0.0) |
| BMI | 0 (0.0) | 0 (0.0) |
| BMI at age 25 | 146 (3.5) | 162 (6.9) |
| Height in men | 0 (0.0) | 0 (0.0) |
| Height in women | 0 (0.0) | 0 (0.0) |
| Smoker | 36 (0.9) | 0 (0.0) |
| Systolic blood pressure | 3 (0.1) | 10 (0.4) |
| Diastolic blood pressure | 3 (0.1) | 10 (0.4) |
| Total cholesterol | 20 (0.5) | 8 (0.3) |
| **2nd Evaluation** |  |  |
| Age | 0 (0.0) | 0 (0.0) |
| BMI | 0 (0.0) | 0 (0.0) |

BMI, body mass index, HBS, Helsinki Businessmen study

**eTable 3. Additional sample characteristics for primary cohorts**

| Characteristic | All (n=4118) | Persistent healthy weight (n = 2161) | Weight loss (n = 96) | Weight gain (n = 565) | Persistent overweight (n = 1296) | Pvalue | | All (n=2335) | Persistent healthy weight (n = 750) | Weight loss (n = 188) | Weight gain (n = 170) | Persistent overweight (n = 1227) | P-value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Whitehall II study** | | | | | | | **Helsinki Businessmen study** | | | | |
| Mean (SD) systolic BP, 2nd evaluation, mmHg | 118.8 (12.7) | 116.3 (12.4) | 117.5 (14.3) | 118.9 (11.2) | 123.2 (12.6) | <0.001 | | 143 (18.9) | 139 (18.7) | 141 (20.6) | 140 (17.8) | 146 (18.3) | <0.001 |
| Mean (SD) diastolic BP, 2nd evaluation, mmHg | 79.1 (9.3) | 76.7 (8.8) | 76.6 (10.0) | 80.2 (8.2) | 82.8 (9.1) | <0.001 | | 92 (11.3) | 88 (10.9) | 89 (11.0) | 91 (10.9) | 95 (11.0) | <0.001 |
| Mean (SD) serum total cholesterol, 2nd evaluation, mg/dL | 243.4 (43.5) | 236.5 (41.1) | 231.3 (41.1) | 251.2 (44.2) | 252.3 (45.0) | <0.001 | | 243 (41.1) | 237 (39.2) | 237 (39.2) | 251 (42.8) | 246 (41.7) | <0.001 |
| Mean (SD) 1-hr glucose at 1st evaluation, mg/dL | | | | | | | | 114 (33.5) | 106 (28.4) | 117 (36.0) | 110 (27.1) | 118 (35.8) | <0.001 |
| Post-load glucose 162 mgl/dL or higher[a], % | | | | | | | | 20 (8.8) | 32 (4.3) | 20 (10.4) | 7 (4.2) | 148 (12.1) | <0.001 |
| Mean (SD) 1-hr glucose at 2nd evaluation, mg/dL | | | | | | | | 129 (39.1) | 120 (33.3) | 123 (38.8) | 128 (35.2) | 135 (41.6) | <0.001 |
| Post-load glucose 162 mg/dL or higher[a], ( %) | | | | | | | | 429 (18.4) | 86 (11.4) | 27 (14.6) | 25 (14.7) | 279 (22.7) | <0.001 |
| Mean (SD) 2-hr glucose at 2nd evaluation, mg/dL | 97.5 (30.7) | 94.9 (28.0) | 93.4 (27.5) | 96.8 (29.1) | 102.5 (35.0) | <0.001 | | | | | | | |
| Post-load glucose 141 mg/dL or higher[b], No. (%) | 300 (7.7) | 124 (6.0) | 5 (5.4) | 41 (7.8) | 130 (10.7) | <0.001 | | | | | | | |
| Low physical activity, 1st evaluation, No. (%) | 477 (11.7) | 217 (10.1) | 15 (15.8) | 55 (9.9) | 190 (14.9) | <0.001 | | | | | | | |
| Low physical activity, 2nd evaluation, No. (%) | 660 (16.4) | 296 (13.9) | 15 (16.0) | 86 (15.9) | 263 (21.0) | <0.001 | | | | | | | |

[a] Threshold of prediabetes for 1-hour postload glucose.

[b] Threshold of prediabetes for 2-hour postload glucose.

To convert serum total cholesterol from mg/dL to mmol/l, multiply by 0.0258. To convert serum glucose from mg/dL to mmol/l, multiply by 0.0555.
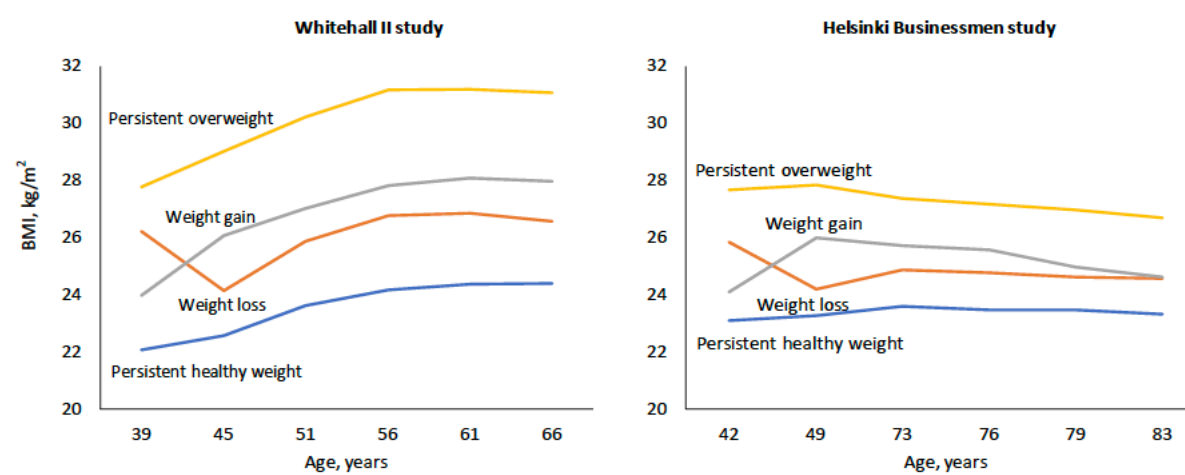
**eFigure 1. BMI trajectories by weight group in primary cohorts**

**eTable 4. Association of weight group with all-cause death among participants (n=1743) of the Helsinki Businessmen Study without chronic medications or diseases listed in eTable 1.**

| Weight group | N (incident cases/deaths) | Hazard ratio (95% confidence interval) | | |
|---|---|---|---|---|
| | | Model 1[a] | Model 2[b] | Model 3[c] |
| | | Outcome: Death (Helsinki Businessmen study) | | |
| Persistent healthy weight | 592 (474) | 0.77 (0.69-0.87) | 0.79 (0.70-0.88) | 0.83 (0.74-0.94) |
| Weight loss | 127 (99) | 0.78 (0.63-0.96) | 0.76 (0.61-0.93) | 0.79 (0.63-0.97) |
| Weight gain | 129 (106) | 0.92 (0.75-1.13) | 0.97 (0.79-1.18) | 1.04 (0.84-1.27) |
| Persistent overweight | 895 (785) | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) |

[a] Unadjusted
[b] Adjusted for age
[c] Adjusted for age, smoking, systolic blood pressure and total cholesterol at 1st evaluation

**eTable 5. Association of weight change with incident chronic disease and death after adjustment for change in BMI during the follow-up in primary analysis**

| Weight group | Total No. (Cases No.) | Hazard ratio (95% confidence interval)[a] |
|---|---|---|
| | | Outcome: First chronic disease (Whitehall) |
| Persistent healthy weight | 2129 (627) | 0.61 (0.54-0.69) |
| Weight loss | 94 (25) | 0.52 (0.35-0.77) |
| Weight gain | 559 (203) | 0.77 (0.66-0.91) |
| Persistent overweight | 1278 (577) | 1.00 (reference) |
| | | Outcome: First chronic disease except diabetes (Whitehall) |
| Persistent healthy weight | 2129 (535) | 0.72 (0.63-0.82) |
| Weight loss | 94 (20) | 0.58 (0.37-0.91) |
| Weight gain | 559 (166) | 0.85 (0.71-1.02) |
| Persistent overweight | 1278 (438) | 1.00 (reference) |
| | | Outcome: Death (Helsinki Businessmen study) |
| Persistent healthy weight | 747 (611) | 0.87 (0.79-0.97) |
| Weight loss | 184 (150) | 0.85 (0.71-1.01) |
| Weight gain | 169 (142) | 0.99 (0.83-1.18) |
| Persistent overweight | 1217 (1085) | 1.00 (reference) |

[a] Adjusted for age, sex, smoking, systolic blood pressure and BMI change during follow-up

**eTable 6. Number (%) of missing values in the replication cohort (Finnish Public Sector study)**

| | FPS |
|---|---|
| **1st Evaluation** | |
| Age | 0 (0.0) |
| BMI | 0 (0.0) |
| BMI at age 25 | – |
| Height in men | 0 (0.0) |
| Height in women | 0 (0.0) |
| Smoker | 4 (0.02) |
| Hypertension | 0 (0.0) |
| **2nd Evaluation** | |
| Age | 0 (0.0) |
| BMI | 0 (0.0) |

BMI, body mass index, FPS, Finnish Public Sector study.

**eTable 7. Characteristics of the participants in the replication cohort (Finnish Public Sector study)**

| Characteristic | Weight change between 1st and 2nd evaluation[a] (FPS) | | | | | |
|---|---|---|---|---|---|---|
| | All (n=16696) | Persistent healthy weight (n = 8618) | Weight loss (n = 332) | Weight gain (n = 1847) | Persistent overweight (n = 5899) | P-value |
| **1st Evaluation** | | | | | | |
| Proportion of men, No. (%) | 2911 (17.4) | 979 (11.4) | 71 (21.4) | 337 (18.3) | 1524 (25.8) | <0.001 |
| Age, median (IQR), y | 39 (34–43) | 39 (33–43) | 40 (36–44) | 39 (34–43) | 40 (35–44) | <0.001 |
| Mean (SD) BMI, kg/m$^2$ | 24.5 (4.1) | 21.6 (1.6) | 26.1 (1.7) | 23.9 (1.1) | 28.8 (3.5) | <0.001 |
| Obesity, No. (%) | 1627 (9.7) | 0 (0.0) | 8 (2.4) | 0 (0.0) | 1619 (27.5) | <0.001 |
| Mean (SD) height in men, cm | 180 (6.2) | 180 (6.2) | 180 (6.1) | 180 (6.4) | 180 (6.3) | 0.66 |
| Mean (SD) height in women, cm | 166 (5.8) | 166 (5.7) | 166 (6.1) | 166 (5.8) | 165 (5.8) | <0.001 |
| Current smoker, No. (%) | 2943 (17.6) | 1238 (14.4) | 69 (20.8) | 375 (20.3) | 1261 (21.4) | <0.001 |
| Ex-smoker, No. (%) | 2920 (17.5) | 1398 (16.2) | 58 (17.5) | 303 (16.4) | 1161 (19.7) | <0.001 |
| Current or ex-smoker, No. (%) | 5863 (35.1) | 2636 (30.6) | 127 (38.3) | 678 (36.7) | 2422 (41.1) | <0.001 |
| Hypertension, No. (%) | 452 (2.7) | 115 (1.3) | 11 (3.3) | 50 (2.7) | 276 (4.7) | <0.001 |
| **2nd Evaluation** | | | | | | |
| Age, median (IQR), y | 43 (38–47) | 42 (37–47) | 44 (40–47) | 43 (38–47) | 44 (39–47) | <0.001 |
| Mean (SD) years since 1st evaluation | 3.7 (0.7) | 3.7 (0.8) | 3.9 (0.7) | 3.9 (0.7) | 3.7 (0.7) | <0.001 |
| Mean (SD) BMI, kg/m$^2$ | 25.2 (4.4) | 21.9 (1.6) | 23.5 (1.2) | 26.4 (1.6) | 29.6 (3.7) | <0.001 |
| Obesity, No. (%) | 2160 (12.9) | 0 (0.0) | 0 (0.0) | 42 (2.3) | 2118 (35.9) | <0.001 |
| Mean (SD) weight change, kg | 1.9 (5.1) | 0.9 (2.9) | -7.3 (7.0) | 6.9 (5.4) | 2.3 (6.0) | <0.001 |
| Relative (SD) weight change, % | 2.9 (7.0) | 1.6 (4.9) | -9.5 (7.1) | 10.5 (9.2) | 3.0 (6.8) | <0.001 |

[a] The first and second evaluations were in 2000-2002 and 2004-2005 in the Finnish Public Sector study (FPS).
Abbreviations. BMI, body mass index; IQR, interquartile range; SE, standard error; y, year.


**eTable 8. Association of weight change with incident chronic disease and death after adjustment for change in BMI during the follow-up in the replication analysis**

| Weight group | Total No. (Cases No.) | Hazard ratio (95% confidence interval)[a] |
|---|---|---|
| | | Outcome: First chronic disease (FPS) |
| Persistent healthy weight | 8618 (616) | 0.44 (0.39-0.48) |
| Weight loss | 332 (23) | 0.45 (0.30-0.68) |
| Weight gain | 1847 (174) | 0.61 (0.52-0.72) |
| Persistent overweight | 5899 (1035) | 1.00 (reference) |
| | | Outcome: First chronic disease except diabetes (FPS) |
| Persistent healthy weight | 8618 (570) | 0.71 (0.63-0.79) |
| Weight loss | 332 (16) | 0.55 (0.34-0.91) |
| Weight gain | 1847 (142) | 0.90 (0.75-1.08) |
| Persistent overweight | 5899 (583) | 1.00 (reference) |

[a] Adjusted for age, sex, smoking, systolic blood pressure and BMI change during follow-up

**eTable 9. Association of weight change with incident chronic disease in men (Whitehall II study)**

| Weight group | No. Total | No. Cases | Hazard ratio (95% confidence interval)[a] |
|---|---|---|---|
| | | | Outcome: First chronic disease |
| Persistent healthy weight | 1538 | 458 | 0.65 (0.56-0.74) |
| Weight loss | 72 | 20 | 0.57 (0.36-0.89) |
| Weight gain | 405 | 153 | 0.86 (0.71-1.04) |
| Persistent overweight | 953 | 421 | 1.00 (reference) |
| | | | Outcome: First chronic disease except diabetes |
| Persistent healthy weight | 1538 | 383 | 0.75 (0.64-0.87) |
| Weight loss | 72 | 16 | 0.61 (0.37-1.01) |
| Weight gain | 405 | 124 | 0.94 (0.76-1.16) |
| Persistent overweight | 953 | 321 | 1.00 (reference) |

[a]Adjusted for age, sex, smoking, and systolic blood pressure at first evaluation

**eTable 10. Association of weight change with incident chronic disease in women (Finnish Public Sector study)**

| Weight group | N(total) | N(cases) | Hazard ratio (95% confidence interval)[a] | | |
|---|---|---|---|---|---|
| | | | All | Women aged < 50 y | Women aged 50+ y |
| | | | **Outcome: First chronic disease** | | |
| Persistent healthy weight | 7639 | 559 | 0.42 (0.38-0.47) | 0.45 (0.38-0.53) | 0.40 (0.34-0.46) |
| Weight loss | 261 | 18 | 0.42 (0.26-0.66) | 0.48 (0.25-0.93) | 0.37 (0.19-0.71) |
| Weight gain | 1510 | 135 | 0.55 (0.46-0.66) | 0.52 (0.39-0.68) | 0.58 (0.46-0.74) |
| Persistent overweight | 4375 | 800 | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) |
| | | | **Outcome: First chronic disease except diabetes** | | |
| Persistent healthy weight | 7639 | 519 | 0.69 (0.61-0.78) | 0.72 (0.60-0.87) | 0.67 (0.56-0.79) |
| Weight loss | 261 | 14 | 0.58 (0.34-0.98) | 0.63 (0.30-1.33) | 0.53 (0.25-1.13) |
| Weight gain | 1510 | 115 | 0.84 (0.68-1.03) | 0.75 (0.54-1.02) | 0.91 (0.70-1.20) |
| Persistent overweight | 4375 | 464 | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) |

[a]Adjusted for age, sex, smoking, and systolic blood pressure at first evaluation

**eAppendix**
**Statistical code (SAS, version 9.4):**

```
*****************************************************************;
***  Weight change vs. incident chronic disease  ***;
*****************************************************************;
proc freq data=b1;
     tables bmic*(status_dis status_nondb status_mort) / nopercent nocol;
run;
proc phreg data=b;
     class bmic(ref='4');
     model ftime_dis*status_dis(0) = bmic / rl;
*    model ftime_nondb*status_nondb(0) = bmic / rl;
*    model ftime_mort*status_mort(0) = bmic / rl;
run;
proc phreg data=b1;
     class bmic(ref='4');
     model ftime_dis*status_dis(0) = sex age bmic / rl;
*    model ftime_nondb*status_nondb(0) = sex age bmic / rl;
*    model ftime_mort*status_mort(0) = sex age bmic / rl;
run;
proc phreg data=b1;
     class smoke bmic(ref='4');
     model ftime_dis*status_dis(0) = sex age hypert smoke bmic / rl;
*    model ftime_nondb*status_nondb(0) = sex age hypert smoke bmic / rl;
*    model ftime_mort*status_mort(0) = sex age hypert smoke bmic / rl;
run;


*****************************************************************;
***  Cumulative incidence of chronic disease  ***;
*****************************************************************;
proc phreg data=b1;
     model ftime_dis*status_dis(0) = ;
     strata bmic;
     baseline out=apu1 survival=survival;
run;
data apu2;
     set apu1;
     rename ftime_dis=time bmic=group;
run;
data apu3;
     set apu2;
     by group;
     retain prehazard 0;
     hazard=1-survival;
     if (hazard>. and hazard NE prehazard) or first.group;
     prehazard=hazard;
     keep group time hazard;
data apu4;
     set apu3;
     retain prehazard pregroup 0;
     if group=pregroup then do;
        cumhazard=prehazard; output; end;
     cumhazard=hazard; output;
     pregroup=group;
     prehazard=hazard;
     keep group time cumhazard;
data apu4;
     set apu4;
     cumhazard=100*cumhazard; ** % **;
run;
proc print data=apu4; ** => Excel figure **;
run;
** Number at risk **;
data n1;
     set b1;
     f0n=0; f4n=0; f8n=0; f12n=0;
     if ftime_dis>=0 then f0n=1;
     if ftime_dis>=4 then f4n=1;
     if ftime_dis>=8 then f8n=1;
     if ftime_dis>=12 then f12n=1;
run;
proc means data=n1 sum;
     var f0n--f12n;
     class bmic;
run;


*****************************************************************;
***  Adjustment for change in BMI during the follow-up  ***;
*****************************************************************;
data b2;
     set b1;
     if bmi3>. then do; bmichange3=bmi3-bmi2; time3=age3-age2; end;
     if bmi4>. then do; bmichange4=bmi4-bmi2; time4=age4-age2; end;
     if bmi5>. then do; bmichange5=bmi5-bmi2; time5=age5-age2; end;
run;
proc phreg data=b2;
     class smoke bmic(ref='4');
     model ftime_dis*status_dis(0)= sex age smoke hypert timedep_bmi bmic / rl;
     timedep_bmi=0;
     if time3>0 and ftime_dis>=time3 then timedep_bmi=bmichange3;
```

```
        if time4>0 and ftime_dis>=time4 then timedep_bmi=bmichange4;
        if time5>0 and ftime_dis>=time5 then timedep_bmi=bmichange5;
run;


*********************************************************************;
***  Weight change vs. incident chronic disease / WOMEN  ***;
*********************************************************************;
data women;
     set b1;
     IF sex=2;
     time50=50-age2;

     *women aged <50 years*;
/*   IF ftime_dis>time50 then do; ftime_dis=time50; status_dis=0; end;  */
/*   IF ftime_nondb>time50 then do; ftime_nondb=time50; status_nondb=0; end; */

     *women aged 50+ years*;
/*   IF ftime_dis>=time50; ftime_dis= ftime_dis-time50; age=50; */
/*   IF ftime_nondb>=time50; ftime_nondb= ftime_nondb-time50; age=50; */
run;
proc freq data=women;
     tables bmic* status_dis/ nopercent nocol;
*    tables bmic* status_nondb/ nopercent nocol;
run;
proc phreg data=women;
     class bmic(ref='4');
     model ftime_dis* status_dis (0) = sex age hypert smoke bmic / rl;
*    model ftime_nondb* status_nondb (0) = sex age hypert smoke bmic / rl;
run;
```