

KATHOLIEKE UNIVERSITEIT
LEUVEN

Metabool Syndroom & Lichamelijke Activiteit

Prof.dr. Luc Vanhees
Leiden, 26/9/2007

Metabool Syndroom

(Lakka et al, Appl Physiol Nutr Metab, 2007)

MS & Lichamelijke Activiteit

- Preventie:
 - Relatie tussen fysieke (in)activiteit en metabool syndroom
- Behandeling
 - Effecten
 - Soort training?
 - Conclusie
- Aanbevelingen

MS & Preventie: Sedentaire Leefstijl

Television Watching and Other Sedentary Behaviors in Relation to Risk of Obesity and Type 2 Diabetes Mellitus in Women

Hu, FB, Li TY, Colditz, GA, Willett WC, Manson JE, JAMA, 289:1785-1791, 2003

MS & Preventie: Sedentaire Leefstijl Nurses' Health Study

Analyse Obesiteit (BMI >30) : n=50277 → na 6 jr FU: 3757 subjects obese

| | No. of Hours | | | | | P for Trend |
|-----------------------------------|--------------|------------------|------------------|------------------|------------------|-------------|
| | 0-1 | 2-5 | 6-20 | 21-40 | >40 | |
| Sitting while watching television | 226 | 872 | 2043 | 530 | 86 | |
| Person-years | 21 242 | 70 616 | 148 425 | 26 659 | 5 198 | |
| Age-adjusted RR (95% CI) | 1.00 | 1.23 (1.06-1.42) | 1.42 (1.24-1.63) | 1.69 (1.43-1.96) | 2.00 (1.55-2.57) | <.001 |
| Multivariate RR (95% CI)* | 1.00 | 1.24 (1.07-1.42) | 1.44 (1.25-1.66) | 1.67 (1.43-1.95) | 1.97 (1.53-2.55) | <.001 |
| Multivariate RR (95% CI)† | 1.00 | 1.22 (1.06-1.42) | 1.42 (1.24-1.63) | 1.65 (1.41-1.93) | 1.94 (1.51-2.49) | <.001 |

Analyse Diabetes type 2: n=68497 → na 6 jr FU: 1515 subject Diabetes 2

| | No. of Hours | | | | | P for Trend |
|-----------------------------------|--------------|------------------|------------------|------------------|------------------|-------------|
| | 0-1 | 2-5 | 6-30 | 21-40 | >40 | |
| Sitting while watching television | 81 | 315 | 810 | 258 | 51 | |
| Person-years | 27 966 | 87 533 | 208 128 | 54 810 | 5003 | |
| Age-adjusted RR (95% CI) | 1.00 | 1.10 (0.86-1.43) | 1.30 (1.04-1.64) | 1.53 (1.19-1.96) | 1.98 (1.30-2.81) | <.001 |
| Multivariate RR (95% CI)* | 1.00 | 1.10 (0.86-1.41) | 1.33 (1.06-1.68) | 1.49 (1.16-1.92) | 1.77 (1.24-2.52) | <.001 |
| Multivariate RR (95% CI)† | 1.00 | 1.09 (0.85-1.39) | 1.30 (1.03-1.63) | 1.44 (1.12-1.85) | 1.70 (1.20-2.43) | <.001 |

(Hu et al, JAMA, 2003)

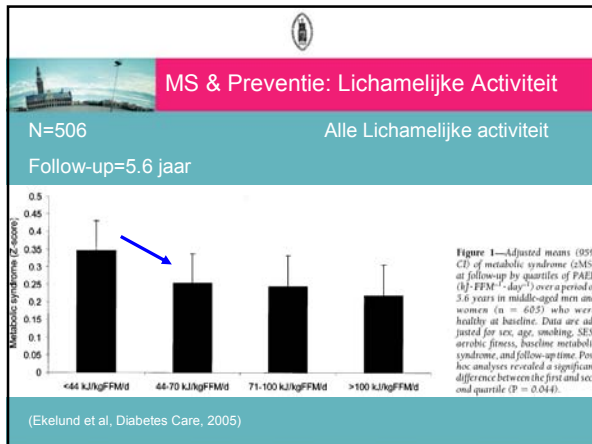
MS & Preventie: Sedentaire Leefstijl

Figure 1. Percentage Changes in Risk of Developing Obesity Among Nonobese Women and in Risk of Developing Type 2 Diabetes Among Nonobese Women Accrualized With Television [TV] Watching, Other Sedentary Behavior, and Walking

(Hu et al, JAMA, 2003)

Dia 1

A1 Administrator; 26-9-2007



MS & Preventie: Lichamelijke Activiteit

N=5153
Self-reported leisure time physical activity

Table 4 Odds ratios (and 95% CI) for metabolic syndrome for vigorous activity ($n = 4945$) and moderate activity adjusted for body mass index (BMI) and resting heart rate (HR)^a ($n = 2722$)

| Model | Base | Base + BMI | Base + HR | Base + BMI + HR |
|--|-------------------|-------------------|-------------------|-------------------|
| Vigorous activity category MET h/week | | | | |
| None ($n = 2722$) | 1 | 1 | 1 | 1 |
| <5 ($n = 192$) | 0.70 (0.52, 0.94) | 0.88 (0.65, 1.21) | 0.75 (0.55, 1.01) | 0.91 (0.67, 1.23) |
| 6–12.5 ($n = 718$) | 0.77 (0.59, 1.00) | 0.84 (0.71, 1.26) | 0.84 (0.65, 1.10) | 1.01 (0.76, 1.34) |
| >12.5 ($n = 913$) | 0.53 (0.41, 0.69) | 0.64 (0.47, 0.85) | 0.61 (0.47, 0.80) | 0.69 (0.51, 0.92) |
| <i>P</i> for trend | <0.001 | 0.005 | <0.001 | 0.01 |
| Moderate activity category MET h/week | | | | |
| <24 ($n = 1349$) | 1 | 1 | 1 | 1 |
| ≥24 ($n = 1373$) | 0.78 (0.63, 0.98) | 0.84 (0.66, 1.07) | 0.82 (0.65, 1.02) | 0.88 (0.69, 1.12) |
| <i>P</i> -value | 0.03 | 0.16 | 0.08 | 0.29 |

Only those who reported no vigorous activity included in the moderate activity analyses Base+sex, age, smoking, high alcohol intake, and grade into moderate activity in vigorous activity models.

(Rennie et al, Int J Epidemiology, 2003)

MS & Preventie: Lichamelijke Activiteit

| No. of cases | Person-years | Relative risk* (95% confidence interval) | | |
|--|--------------|--|------------------|-------------------------|
| | | Model 1 | Model 2 | Model 3 |
| Occupational physical activity | | | | |
| Light | 67250 | 1.00 | 1.00 | 1.00 |
| Moderate | 48184 | 0.57 (0.43-0.76) | 0.66 (0.49-0.90) | 0.70 (0.52-0.96) |
| Active | 55695 | 0.76 (0.60-0.97) | 0.73 (0.56-0.94) | 0.74 (0.57-0.95) |
| <i>p</i> value for trend | | < 0.001 | 0.008 | 0.020 |
| Walking or traveling to/from work | | | | |
| 0 min/d | 242 | 1.00 | 1.00 | 1.00 |
| 1-29 min/d | 93 | 0.75 (0.59-0.96) | 0.88 (0.68-1.15) | 0.96 (0.74-1.25) |
| ≥ 30 min/d | 38 | 0.42 (0.30-0.59) | 0.54 (0.38-0.77) | 0.64 (0.45-0.92) |
| <i>p</i> value for trend | | < 0.001 | 0.003 | 0.048 |
| Leisure-time physical activity | | | | |
| Low | 56387 | 1.00 | 1.00 | 1.00 |
| Moderate | 88350 | 0.63 (0.50-0.78) | 0.67 (0.53-0.84) | 0.81 (0.61-1.02) |
| Active | 26392 | 0.52 (0.36-0.75) | 0.61 (0.41-0.90) | 0.84 (0.57-1.25) |
| <i>p</i> value for trend | | < 0.001 | 0.001 | 0.186 |

*Model 1, adjusted for age, sex, and study year; Model 2, adjusted for the factors in Model 1, plus systolic blood pressure, smoking status, education, and the 2 other kinds of physical activity; Model 3, adjusted for the factors in Model 2, plus body mass index.

(Hu et al, Appl Physiol Nutr Metab 2007; 32:583-595)

UPLIFT Studie (N=1440) – Lichamelijke Activiteit

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Metabool Syndroom (NCEP ATP III richtlijnen)

Vanhees et al, 2007 (unpublished)

| Afhankelijke variabelen | Metabool syndroom JA | Metabool syndroom NEE | Totaal (N) |
|--------------------------|----------------------|-----------------------|--------------|
| Leeftijd (jaars) | 44.5 ± 0.62*** | 37.7 ± 0.35 | 40.4 ± 0.51 |
| Geslacht | | | |
| Man/vrouw (%) | 80.1/19.9** | 65.3/34.7 | 77.2 |
| Man/vrouw (n) | 165/41 | 607/322 | 363 |
| Roker | 27.7% (n=56)* | 20.9% (n=191) | 247 |
| Ex-roker | 46.0% (n=92)** | 33.3% (n=281) | 363 |
| Functie | | | |
| Executief | 70.4% (n=140) | 75.5% (n=701) | 846 |
| Administratief | 29.6% (n=61) | 24.5% (n=236) | 288 |
| Activiteiten | | | |
| Hoewelheid (min/week) | 2000 ± 80.9* | 2208 ± 26.1 | 2198 ± 60.0 |
| Gem. intensiteit (MET/h) | 3.09 ± 0.02* | 3.01 ± 0.02 | 3.05 ± 0.025 |
| Sport | | | |
| Hoewelheid (min/week) | 151 ± 22.0* | 220 ± 13.7 | 186 ± 17.9 |
| Gem. intensiteit (MET/h) | 3.79 ± 0.24*** | 5.08 ± 0.11 | 4.44 ± 0.18 |
| Sport + activiteit | | | |
| Hoewelheid (min/week) | 2236 ± 85.0** | 2508 ± 41.7 | 2372 ± 63.4 |
| Gem. intensiteit (MET/h) | 3.32 ± 0.05 | 3.39 ± 0.03 | 3.36 ± 0.04 |

Waarden zijn gemiddelden en % (n) of gemiddelde ± SE.
Executief: executief operationeel, executief ondernemend, leidgend, uitvoerend. Administratief: administratief, uitvoerend, ondersteunend of functioneel.

MS & Lichamelijke activiteit

UPLIFT Studie (N=1440) – Lichamelijke Activiteit

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Metabool Syndroom (NCEP ATP III richtlijnen)

Vanhees et al, 2007 unpublished

Table 4: De β -coëfficiënt en partiële R^2 van de regressies tussen het metabool syndroom en de hoeveelheid en de gemiddelde intensiteit van de activiteiten en de sportbeoefening.

| | Hoewelheid (min/week) | | |
|---------------------------------|-----------------------|---------------------|---------------------|
| | Activiteit | Sport | Totaal |
| Univariate | -0.0002 (0.0044)* | -0.0006 (0.0041)** | -0.00028 (0.0075)** |
| Correctie leeftijd, gesl | -0.00023 (0.0063)* | -0.00004 (0.0016) | -0.00026 (0.0064)** |
| Correctie leeftijd, gesl, admin | -0.00003 (0.0091)* | -0.00003 (0.0114) | -0.00028 (0.0050)** |
| R^2 | 0.0001 | 0.0001 | 0.0001 |
| Gemiddelde intensiteit (MET/h) | | | |
| | Activiteit | Sport | Totaal |
| | Univariate | 0.009 (0.0045)* | -0.0183 (0.0236)*** |
| Correctie leeftijd, gesl | 0.0087 (0.0022) | -0.0121 (0.0191)** | -0.0071 (0.0017) |
| Correctie leeftijd, gesl, admin | 0.0019 (0.0033) | -0.0118 (0.0098)*** | -0.0047 (0.0050)*** |
| R^2 | 0.0019 | 0.0019 | 0.0019 |

Waarden zijn gepresenteerd als β -coëfficiënt (partieel R^2).
Min/week, minuten per week; leeftijd, geslacht, admin, functie; gemiddelde, gemiddelde.

UPLIFT Studie (N=1440) – Lichamelijke Activiteit

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Metabool Syndroom (NCEP ATP III richtlijnen)

Vanhees et al, 2007 unpublished

| Afhankelijke variabelen | Metabool syndroom Ja | Metabool syndroom nee |
|----------------------------|----------------------|-----------------------|
| leeftijd | 45 ± 10*** | 38 ± 11 |
| geslacht vrouw (%) | 19,9*** | 34,7 |
| Roker (%) | 27,7* | 20,8 |
| Ex-roker (%) | 46,0*** | 33,3 |
| Functie executief (%) | 70,4 | 75,5 |
| Functie administratief (%) | 29,6 | 24,5 |
| VO2 max (ml/min) | 2807 ± 720 | 2849 ± 771 |
| VO2max/kg LG | 30,6 ± 7,5*** | 36,4 ± 7,9 |
| Sedentaire waarden | 105 ± 19** | 112 ± 26 |
| Hfmax | 163 ± 16*** | 170 ± 14 |

MS & Lichamelijke activiteit

- UPLIFT Studie (N=1440)
 - Lichamelijke Fitheid

↓

Metabool Syndroom (NCEP ATP III richtlijnen)

Vanhees et al, 2007 unpublished

| Totale | VO2max | | VO2max/kg | | Sed. Wandel | |
|---|-----------------------|---|--------------------|---|--------------------|---|
| | P.E. | P | P.E. | P | P.E. | P |
| Uniektaat | -0,0001088 (0,001) | | -0,0126 (0,014)*** | | -0,0016 (0,011)*** | |
| Correctie voor leeftijd, geslacht, lengte en gewicht | -0,0001042 (0,001)*** | | -0,0087 (0,016)*** | | -0,0034 (0,008)*** | |
| Correctie voor leeftijd, geslacht, lengte en gewicht en adolinesaai | -0,0001042 (0,001)*** | | -0,0087 (0,016)*** | | -0,0034 (0,008)*** | |

MS & Lichamelijke Activiteit

- Preventie:
 - Relatie tussen fysieke (in)activiteit en metabool syndroom
- Behandeling
 - Effecten
 - Soort training?
 - Conclusie
- Aanbevelingen

MS & Behandeling

- Effect op:
 - Risicofactoren (bloeddruk, lipiden, obesiteit, glucose intolerantie of insuline sensitiviteit)
 - Metabool Syndroom (combinatie risicofactoren)

Behandeling MS - Risicofactoren

- Meta-Analyses
 - Obesiteit
 - Insuline sensitiviteit
 - Dyslipidemie
 - Hypertensie

Risicofactoren – Obesiteit: Fysieke training vs Controle

(Shaw et al. Cochrane Library, 2006)

| Study | Exercise | | No treatment | | Weighted Mean Difference (Fixed) | Weighted Mean Difference (Fixed) |
|----------------|----------|----------|--------------|----------|----------------------------------|----------------------------------|
| | N | Mean(SD) | N | Mean(SD) | | |
| Stefanick 1998 | U | 90 | -0,50 (2,80) | 91 | 0,65 (3,50) | -1,15 [-2,07, -0,23] |
| Thong 2000 | U | 16 | -7,60 (0,40) | 8 | -0,10 (0,80) | -7,50 [-8,09, -6,91] |
| Wood 1988 | U | 47 | -4,00 (3,90) | 42 | 0,60 (3,70) | -4,60 [-6,18, -3,02] |

Δ Gewicht (kg)

| Study | Exercise | | No treatment | | Weighted Mean Difference (Fixed) | Weighted Mean Difference (Fixed) |
|----------------|----------|----------|--------------|----------|----------------------------------|----------------------------------|
| | N | Mean(SD) | N | Mean(SD) | | |
| Andersen 1996 | U | 49 | -0,65 (1,50) | 43 | 0,36 (0,80) | -1,01 [-1,49, -0,53] |
| Hellenius 1993 | U | 39 | -0,30 (0,80) | 39 | 0,30 (0,64) | -0,60 [-0,92, -0,28] |
| Thong 2000 | U | 16 | -2,40 (0,40) | 8 | -0,03 (0,30) | -2,37 [-2,66, -2,08] |

Δ BMI

U= Uithoudingstraining; K= Krachttraining; U/K= 2 aparte trainingsgroepen; U&K= combinatietraining

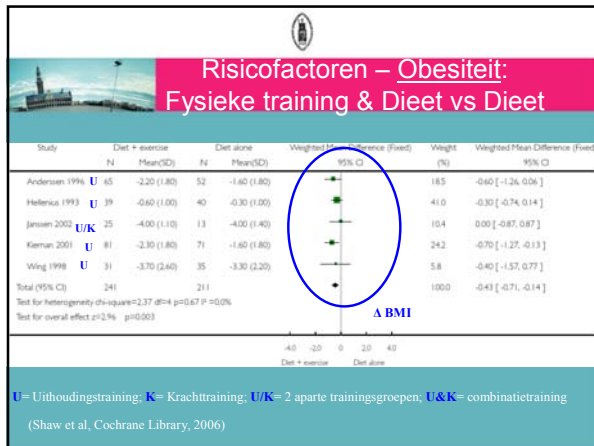
Risicofactoren – Obesiteit: Fysieke training vs Dieet

| Study | Uitdienen | | Dieet | | Weighted Mean Difference (Fixed) | Weighted Mean Difference (Fixed) |
|----------------|-----------|----------|--------------|----------|----------------------------------|----------------------------------|
| | N | Mean(SD) | N | Mean(SD) | | |
| Andersen 1996 | U | 49 | -0,65 (1,50) | 43 | -0,40 (0,80) | 0,25 [-0,31, 0,29] |
| Hellenius 1993 | U | 39 | -0,30 (0,80) | 40 | -0,30 (0,60) | 0,00 [-0,40, 0,40] |
| Thong 2000 | U | 16 | -2,40 (0,40) | 14 | -3,10 (0,80) | 0,70 [-0,46, 0,46] |
| Wing 1988 | U | 33 | 0,80 (1,50) | 26 | -3,20 (2,30) | -4,00 [-4,41, -3,59] |

Δ BMI

U= Uithoudingstraining; K= Krachttraining; U/K= 2 aparte trainingsgroepen; U&K= combinatietraining

(Shaw et al. Cochrane Library, 2006)



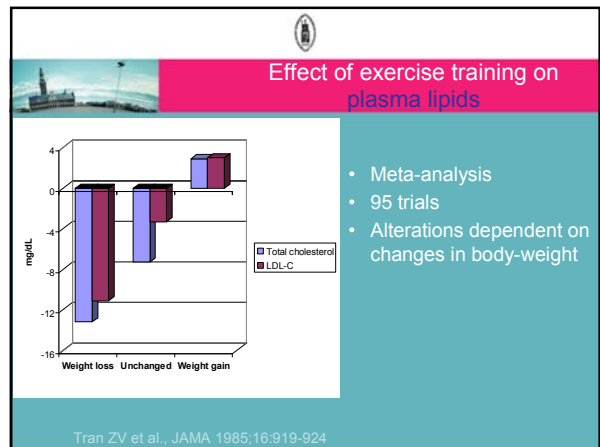
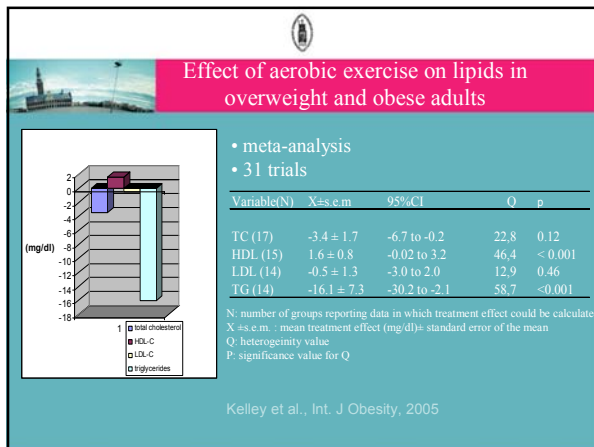
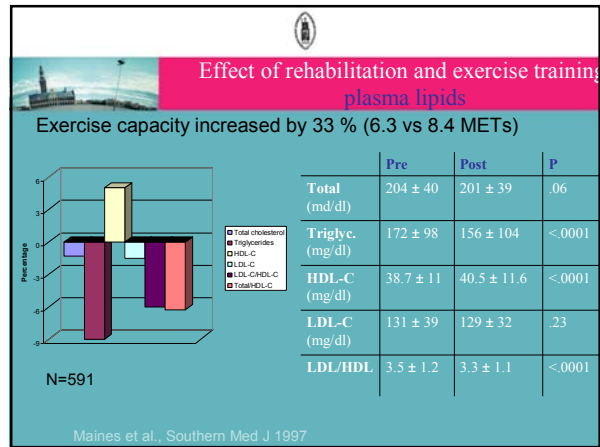
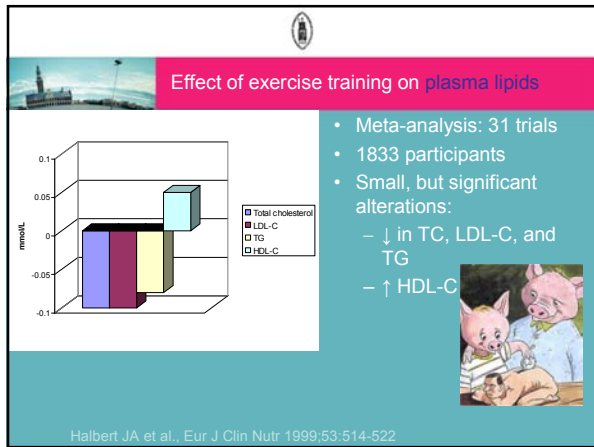
Risicofactoren – Dyslipidemie:

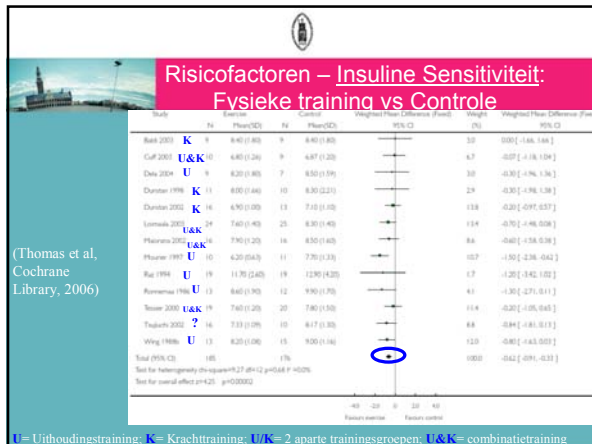
Table 2. Effect of exercise (aerobic and resistance) training on the blood lipid profile

| | Training group | Control group | Change in blood lipid (mmol/L) (95% CI) | WMD (95% CI Random) |
|-------------------------|----------------|---------------|---|---------------------|
| number of studies – 31) | | | | |
| TC | 527 | 614 | 0.10 (0.02, 0.18) | |
| HDL-C | 982 | 842 | -0.05 (-0.08, -0.02) | |
| LDL-C | 843 | 742 | 0.10 (0.02, 0.19) | |
| TG | 907 | 792 | 0.08 (0.02, 0.14) | |
| number of studies – 4*) | | | | |
| TC | 92 | 65 | 0.06 (-0.26, 0.37) | |
| HDL-C | 75 | 56 | -0.05 (-0.19, 0.10) | |
| LDL-C | 75 | 56 | 0.40 (0.07, 0.73) | |
| TG | 79 | 57 | -0.03 (-0.16, 0.09) | |

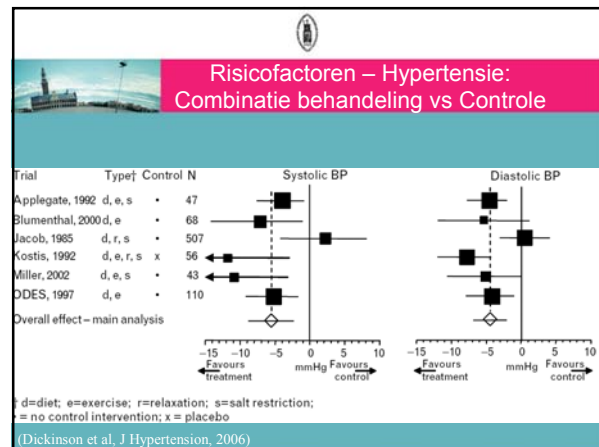
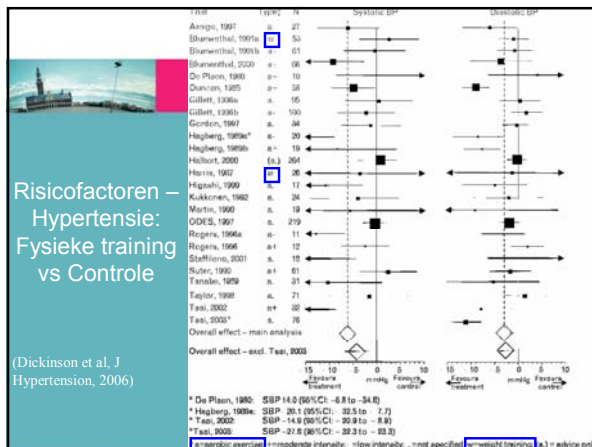
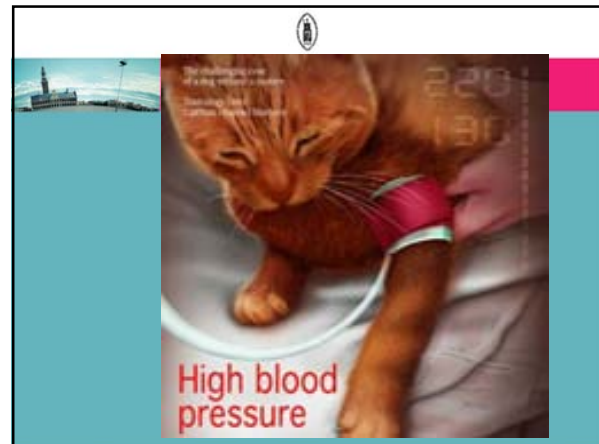
Change expressed as mean change in training Group – mean change in control Group when change is baseline – final lipid values. Weighted mean difference (95% CI Random). *Hershey (1994) included both aerobic and resistance training groups.

(Halbert, Eur J Clin Nutr, 1999)





(Thomas et al, Cochrane Library, 2006)



Effect of exercise training on blood pressure

Baseline data and net changes in response to dynamic exercise training

| | N | Baseline | | Net change | |
|--------------------------------|----|----------------------|----------------------|---------------|---|
| | | Mean (95% CL) | Mean (95% CL) | Mean (95% CL) | P |
| Blood pressure (mmHg) | | | | | |
| Systolic | 68 | 126.2 (123.3; 129.0) | -3.4 (-4.5; -2.3) | <0.001 | |
| Diastolic | 68 | 79.9 (77.9; 82.0) | -2.4 (-3.2; -1.6) | <0.001 | |
| Peak oxygen uptake (ml/min/kg) | 59 | 31.4 (29.6; 33.2) | +3.7 (+3.2; +4.3) | <0.001 | |
| Heart rate (beats/min) | 48 | 71.1 (69.3; 72.9) | -4.9 (-5.9; -3.9) | <0.001 | |
| Body mass index (kg/m) | 64 | 25.6 (25.0; 26.1) | -0.34 (-0.46; -0.22) | <0.001 | |

Values are weighted means and 95% confidence limits (CL).
N: # training groups programs

Meta-analysis by Fagard et al. Journal of human hypertension, 2005

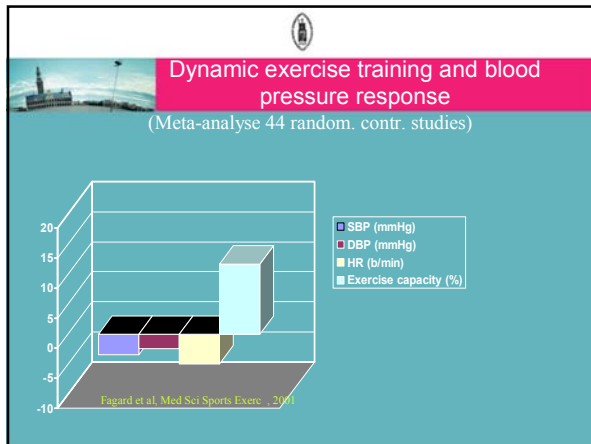
Effect of exercise training on blood pressure (haemodynamic data)

Net haemodynamic changes (%) in response to exercise training

| | N | Mean (95% CL) | P |
|------------------------------|----|---------------------|--------|
| Mean blood pressure | 17 | -4.9 (-7.0; -2.7) | <0.001 |
| Cardiac output | 17 | +1.4 (-4.7; +7.5) | NS |
| Heart rate | 16 | -9.1 (-13.0; -5.2) | <0.001 |
| Stroke volume | 15 | +14.9 (+5.6; +24.2) | <0.01 |
| Systemic vascular resistance | 17 | -7.4 (-13.2; -1.6) | <0.05 |

Values are weighted means and 95% confidence limits (CL).
N=number of study groups.
NS=not significant.

Meta-analysis by Fagard et al. Journal of human hypertension, 2005



Dynamic exercise training and blood pressure response

(in normotensives and hypertensives)

| | Normotensives (n = 210) | Hypertensives (n = 138) | H vs N |
|----------|-------------------------|-------------------------|---------------------|
| Systole | - 3 (+0.5 to -7) | - 13 (-11 to -15) | - 10 (-7 to -12) |
| Diastole | - 2 (+ 1 to -5) | - 8 (-6 to -10) | - 6 (-5 to -6) |

(values are weighted means (95% CL) of 7 studies)

Fagard et al. Handbook of Hypertension, Vol 20: Epidemiology of Hypertension, 2000

Lifestyle changes in the treatment of hypertension

| Lifestyle change | Effect on systolic BP |
|----------------------|-----------------------|
| Weigh loss | 5 – 10 mmHg/10 kg |
| DASH-diet | 8 – 14 mmHg |
| Salt restriction | 2 – 8 mmHg |
| Physical activity | 4 – 9 mmHg |
| Moderate alcohol use | 2 – 4 mmHg |

Chobanian et al. Hypertension, 2003

Determinants of blood pressure response to exercise

Training mode

Endurance training Versus Resistance training

- ### Training mode
- Effect of endurance training on blood pressure: meta-analysis by Cornelissen et al. Hypertension, 2005
 - Effect of resistance training on blood pressure: meta-analysis by Cornelissen et al., Journal of Hypertension, 2005
 - Effect of (isometric) strength training on BP measured in various conditions in sedentary men: Van Hoof et al., Int. J sport med, 1996

Effect of endurance training on VO2max and HR

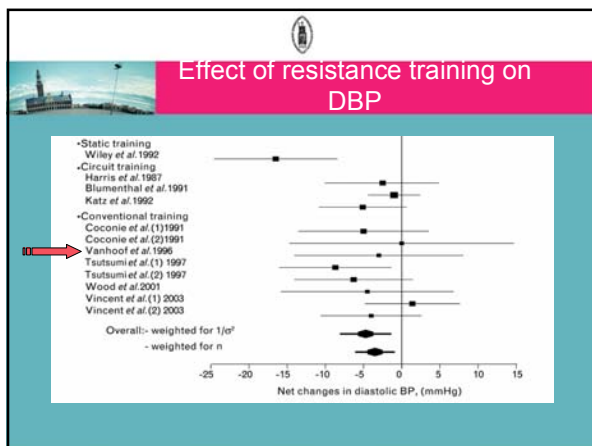
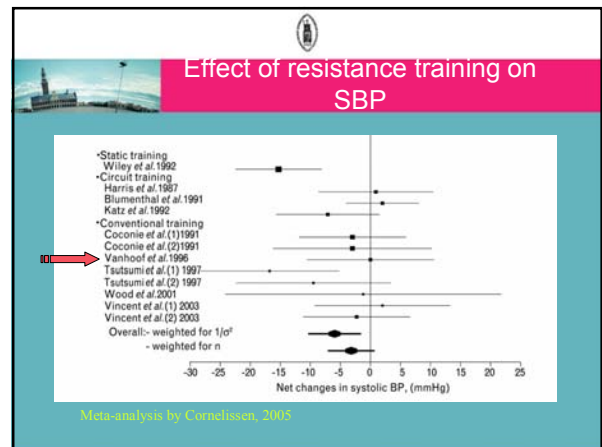
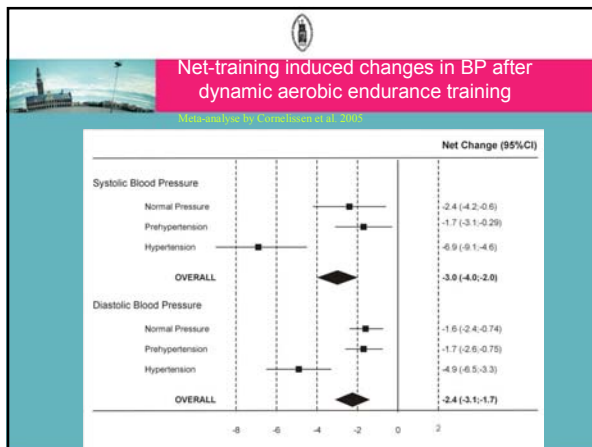
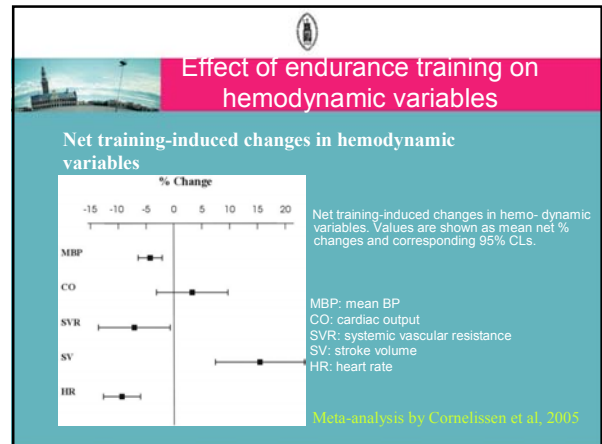
| Variable | Subgroup | N studies | Baseline | Net Change | P Value |
|---------------------|------------------|-----------|-------------------|-------------------|---------|
| VO ₂ max | Normal pressure | 25 | 31.6 (28.9; 34.3) | 3.5 (2.5; 4.4) | <0.001 |
| | Pre-hypertension | 39 | 31.5 (29.5; 33.4) | 3.9 (3.1; 4.6) | <0.001 |
| | Hypertension | 17 | 29.2 (25.6; 32.8) | 4.4 (3.7; 5.1) | <0.001 |
| HR | Normal pressure | 18 | 71.0 (67.1; 74.9) | -7.1 (-9.3; -5.0) | <0.001 |
| | Hypertension | 23 | 74.4 (72.4; 76.3) | -4.5 (-6.5; -2.6) | 0.001 |

Cornelissen, 2005

Effect of endurance training on BP

| variable | subgroups | N studies | baseline | net changes | P value |
|----------|-----------------|-----------|----------------------|--------------------|---------|
| SBP | Normal pressure | 28 | 114.3 (112.8; 115.9) | -2.4 (-4.2; -0.6) | <0.01 |
| | Prehypertension | 46 | 127.2 (125.9; 128.5) | -1.7 (-3.1; -0.29) | <0.05 |
| | Hypertension | 30 | 145.4 (142.4; 148.4) | -6.9 (-9.1; -4.6) | <0.001 |
| DBP | Normal pressure | 28 | 73.0 (71.8; 74.1) | -1.6 (-2.4; -0.75) | <0.001 |
| | Prehypertension | 44 | 80.3 (79; 81.6) | -1.7 (-2.6; -0.75) | <0.001 |
| | Hypertension | 30 | 92.3 (89.5; 95.1) | -4.9 (-6.5; -3.3) | <0.001 |

Cornelissen, 2005



Effect of resistance training

| Variable | Baseline | | Net change | | P value |
|-------------------------------------|----------|---------------------|------------|-----------------------|---------|
| | N | Mean (95% CL) | N | Mean (95% CL) | |
| Blood pressure (mmHg) | | | | | |
| weighted for $1/\sigma^2$ | | | | | |
| Systolic | 12 | 131.6 (123.5-139.6) | 12 | -6.0 (-10.4 to -1.6) | < 0.01 |
| Diastolic | 12 | 80.9 (73.9-87.8) | 12 | -4.7 (-8.1 to -1.4) | < 0.01 |
| weighted for n | | | | | |
| Systolic | 12 | 131.0 (123.0-138.8) | 12 | -3.2 (-7.1 to +0.7) | = 0.10 |
| Diastolic | 12 | 81.1 (74.5-87.7) | 12 | -3.5 (-6.1 to -0.9) | < 0.01 |
| VO ₂ max (ml/min per kg) | 9 | 24.7 (19.2-30.2) | 6 | +2.6 (+0.3 to +4.8) | < 0.05 |
| Heart rate (beats/min) | 10 | 70.7 (66.9-74.4) | 8 | +1.0 (-1.7 to +3.7) | NS |
| Percent body fat (%) | 6 | 30.1 (27.7-32.5) | 4 | -0.94 (-1.6 to -0.25) | < 0.01 |
| Weight (kg) | 8 | 76.4 (69.4-83.4) | 4 | +0.33 (-2.7 to +3.4) | NS |

N, number of trials; n, number of trained participants; VO₂, oxygen uptake. Values are given as weighted mean and 95% confidence limits (CL).

Cornelissen, 2005

Effect of strength training on BP measured in various conditions in sedentary men.

- 30 sedentary men
- Training group <-> control group
- 48 training sessions, 3X/week
- As static or isometric exercise as possible

Van Hoof et al., Int. J. Sports Med. 17 (1996)

Effect of strength training on BP measured in various conditions in sedentary men.

- Strength training affected muscle strength: 1RM values of the various ex. muscles increased significantly
- Strength training did not affect VO₂Max, BP, HR or lipids

Van Hoof et al., Int. J. Sports Med. 17 (1996)

MS & Behandeling

- Effect op:
 - Risicofactoren (bloeddruk, lipiden, obesiteit, insuline resistentie)
 - **Metabool Syndroom** (combinatie risicofactoren)

MS behandeling: fysieke activiteit

Targeting the Metabolic Syndrome with Exercise: Evidence from the HERITAGE Family Study

KATZMARZYK PT, LEON AS, WILMORE JH, SKINNER JS, RAO DC, RANKINEN T, BOUCHARD C, Med Sci Sports Ex, 2003

MS behandeling: fysieke activiteit

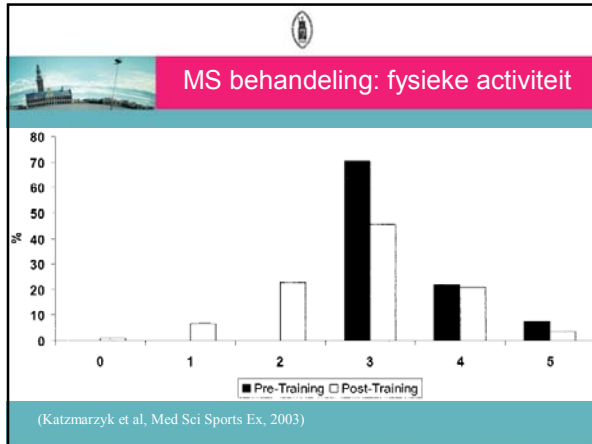
- RCT
- N=621 (sedentair, schijnbaar gezond)
- MS= aanwezigheid ≥ 3 risicofactoren
- Aerobe training= 20 weken onder toezicht
- 3x/week; 30-50 min

(Katzmarzyk et al, Med Sci Sports Ex, 2003)

MS behandeling: fysieke activiteit

(Katzmarzyk et al, Med Sci Sports Ex, 2003)

FIGURE 1—Prevalence of individual risk factors before and after 20 wk of aerobic exercise training in the HERITAGE Family Study among 105 participants with the metabolic syndrome at baseline. *P < 0.05 pre- versus posttraining.



MS behandeling: fysieke activiteit

Exercise and Risk Factors associated with Metabolic Syndrome in Older Adults

KJ Stewart, AC Bacher, K Turner, JG Lim, PS Hees, EP Shapiro, M Tayback, P Ouyang, Am J Prev Med, 2005

MS behandeling: fysieke activiteit

- RCT
- N=115 (55-75 jaar; sedentair)
- 6 maanden training
 - 3x/week
 - Combinatie: Krachttraining (10-15 repetities; 50% 1RM) & Uithoudingstraining (45 min; 60-90% HR max)

(Stewart et al., Am J Prev Med, 2005)

Table 1. Baseline characteristics of randomized participants in RCT (n=115)

| | Exercise | Control | p value* |
|--|---------------------|---------------------|----------|
| Age, years | 65.9 (34.3-94.2) | 64.1 (32.1-92.5) | 0.95 |
| Aerobic and strength fitness, mean (95% CI) | | | |
| Peak oxygen uptake, ml/kg/min | 21.4 (20.6-22.6) | 24.1 (23.5-24.7) | 0.08 |
| Lean muscle strength | 122.1 (114.2-130.1) | 125.6 (116.3-134.9) | 0.97 |
| Body composition, mean (95% CI) | | | |
| Body mass index | 27.4 (26.7-28.1) | 28.2 (28.0-28.5) | 0.75 |
| Weight, kg | 85.2 (81.0-89.4) | 88.5 (86.8-90.2) | 0.53 |
| Waist circumference, cm | 94.9 (93.6-96.2) | 95.0 (91.1-98.9) | 0.60 |
| Waist-hip ratio | 0.9 (0.9-0.9) | 0.9 (0.9-0.9) | 0.75 |
| Abdominal visceral fat (MRI), cm ² | 492.5 (329.9-655.1) | 402.6 (274.2-530.9) | 0.26 |
| Abdominal subcutaneous fat (MRI), cm ² | 146.8 (125.4-168.2) | 142.2 (115.3-169.0) | 0.77 |
| Abdominal subcutaneous fat (DEXA), cm ² | 255.1 (235.4-274.8) | 257.7 (248.5-266.9) | 0.98 |
| Total body fat (DEXA), % | 30.8 (28.4-33.6) | 31.0 (29.4-32.5) | 0.66 |
| Lean body mass (DEXA), % | 69.2 (66.4-72.0) | 69.0 (66.4-71.5) | 0.96 |
| Resting blood pressure, mean (95% CI) | | | |
| Systolic blood pressure, mm Hg | 116.3 (115.0-117.6) | 110.1 (108.9-111.3) | 0.01 |
| Diastolic blood pressure, mm Hg | 76.0 (74.6-77.5) | 75.4 (73.1-77.6) | 0.72 |
| Lipids and lipoproteins, mean (95% CI) | | | |
| Cholesterol, mg/dl | 212.9 (209.9-215.9) | 207.1 (198.9-215.2) | 0.16 |
| High-density lipoprotein cholesterol, mg/dl | 54.5 (53.4-55.6) | 55.1 (51.1-59.1) | 0.27 |
| Low-density lipoprotein cholesterol, mg/dl | 155.4 (153.1-157.7) | 152.0 (147.8-156.2) | 0.75 |
| Very low-density lipoprotein cholesterol, mg/dl | 25.5 (24.0-27.0) | 25.0 (21.1-28.9) | 0.48 |
| Triglycerides, mg/dl | 116.0 (110.5-121.5) | 110.0 (95.7-124.3) | 0.10 |
| Lipoprotein(a), mg/dl | 22.9 (21.1-24.7) | 21.3 (21.2-21.4) | 0.16 |
| Glucose and insulin, mean (95% CI) | | | |
| Glucose, mg/dl | 100.3 (97.7-102.9) | 101.1 (99.2-102.9) | 0.96 |
| Insulin, mIU/ml | 10.7 (10.2-11.2) | 9.8 (9.2-10.4) | 0.21 |
| HOMA-IR | 9.50 (9.39-9.60) | 8.91 (8.33-9.50) | 0.57 |
| Metabolic syndrome risk factors | | | |
| Number of elevated risk factors | 2.3 (2.0-2.6) | 2.0 (2.0-2.0) | 0.08 |
| Diagnosed with metabolic syndrome (%) | 49.6 (37-62) | 41.8 (34-49) | 0.25 |
| CHD risk index, mean (95% CI) ^b | 10.2 (10.1-10.3) | 10.2 (10.1-10.3) | 0.91 |

*p < 0.05 (bilateral); **p < 0.01 (bilateral); ***p < 0.001 (bilateral).
 CI, confidence interval; CHD, coronary heart disease; DEXA, dual-energy x-ray absorptiometry; MRI, magnetic resonance imaging; QSOX3, Quantitative Insulin Sensitivity Check Index.

Table 2. Change in study variables from baseline in exercise and control participants

| | Exercise | Control | Difference | p value* |
|---|---------------------|--------------------|--------------------|-----------|
| Aerobic and strength fitness, mean (95% CI) | | | | |
| Peak oxygen uptake, ml/kg/min | 4.0 (3.2-4.8) | -0.1 (-0.8-0.5) | 4.1 (3.1-5.2) | <0.001*** |
| Total muscle strength, lb | 126.0 (109.1-142.4) | 8.0 (-5.8-21.8) | 118.1 (96.9-139.2) | <0.001*** |
| Body composition, mean (95% CI) | | | | |
| Body mass index ^b | -0.8 (-1.1-0.5) | -0.2 (-0.6-0.1) | -0.7 (-1.1-0.3) | <0.001*** |
| Weight, kg | -2.3 (-3.1-1.4) | -0.5 (-1.2-0.1) | -1.7 (-2.8-0.7) | <0.002** |
| Waist circumference, cm | -2.9 (-4.1-1.7) | -0.8 (-1.8-0.1) | -2.0 (-3.6-0.5) | 0.01* |
| Waist-hip ratio | -0.01 (-0.02-0.00) | -0.01 (-0.01-0.00) | 0.00 (-0.01-0.01) | 0.52 |
| Abdominal total fat (MRI), cm ² | -52.5 (-66.6-38.7) | -6.5 (-20.3-7.5) | -46.0 (-65.4-26.5) | <0.001*** |
| Abdominal visceral fat (MRI), cm ² | -26.7 (-33.6-17.9) | -3.8 (-10.8-3.3) | -22.9 (-34.2-11.8) | <0.001*** |
| Abdominal subcutaneous fat (MRI), cm ² | -25.8 (-35.1-16.5) | -2.9 (-11.5-6.0) | -22.9 (-35.7-10.3) | <0.001*** |
| Total body fat (DEXA), % | -3.5 (0.0-2.8) | -0.2 (0.5-0.5) | -3.3 (-4.1-2.4) | <0.001*** |
| Lean body mass (DEXA), % | 3.5 (2.8-4.2) | 0.2 (-0.3-0.7) | 3.3 (2.4-4.1) | <0.001*** |
| Resting blood pressure, mean (95% CI) | | | | |
| Systolic blood pressure, mm Hg | -5.3 (-8.1-2.5) | -4.5 (-6.7-2.2) | -0.8 (-4.8-3.2) | 0.65 |
| Diastolic blood pressure, mm Hg | -3.7 (-5.1-2.4) | -1.5 (-2.9-0.2) | -2.2 (-4.1-0.3) | 0.02* |
| Heart rate, bpm | -3.9 (-5.4-2.4) | -2.2 (-3.8-0.5) | -1.8 (-4.1-0.5) | 0.12 |
| Lipids and lipoproteins, mean (95% CI) | | | | |
| Cholesterol, mg/dl | -5.2 (-13.3-3.0) | -5.3 (-14.2-3.7) | 0.0 (-1.2-12.0) | 0.99 |
| High-density lipoprotein cholesterol, mg/dl | 3.0 (1.3-4.9) | -0.3 (-2.3-1.5) | 3.3 (0.7-5.9) | 0.01* |
| Low-density lipoprotein cholesterol, mg/dl | -5.7 (-12.5-1.2) | -3.1 (-13.9-7.6) | -6.6 (-11.6-16.5) | 0.02 |
| Very low-density lipoprotein cholesterol, mg/dl | -4.0 (-7.6-0.4) | 0.2 (-2.4-2.8) | -4.2 (-8.6-0.3) | 0.07 |
| Triglycerides, mg/dl | -13.4 (-33.9-6.9) | 1.2 (-11.9-14.2) | -14.6 (-40.3-11.1) | 0.26 |
| Lipoprotein(a), mg/dl | -0.9 (-3.2-1.4) | 1.8 (-2.9-6.5) | -2.7 (-7.9-2.5) | 0.30 |
| Glucose and insulin, mean (95% CI) | | | | |
| Glucose, mg/dl | 0.2 (-2.7-3.0) | 1.7 (-1.5-5.0) | -1.5 (-2.8-0.9) | 0.40 |
| Insulin, mIU/ml | -0.6 (-1.8-0.5) | -0.1 (-1.2-1.0) | -0.6 (-2.3-1.1) | 0.56 |
| QSOX3 | 0.00 (0.00-0.01) | 0.00 (-0.01-0.01) | 0.01 (-0.01-0.01) | 0.21 |
| CHD risk index, mean (95% CI) ^b | -1.0 (-1.8-0.2) | -0.3 (-1.1-0.6) | -0.8 (-0.4-1.9) | 0.18 |

*p < 0.05 (bilateral); **p < 0.01 (bilateral); ***p < 0.001 (bilateral).
 CI, confidence interval; CHD, coronary heart disease; DEXA, dual-energy x-ray absorptiometry; MRI, magnetic resonance imaging; QSOX3, Quantitative Insulin Sensitivity Check Index.

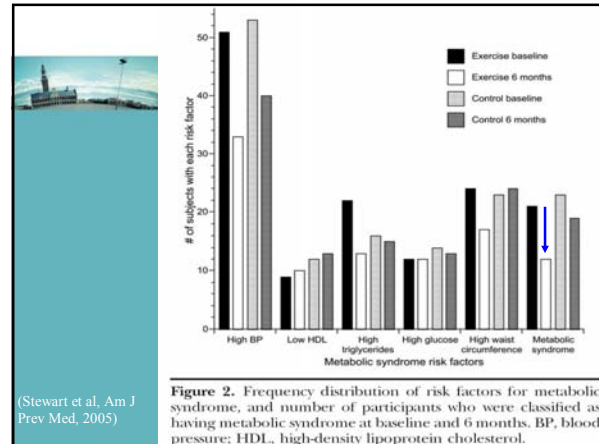


Figure 2. Frequency distribution of risk factors for metabolic syndrome, and number of participants who were classified as having metabolic syndrome at baseline and 6 months. BP, blood pressure; HDL, high-density lipoprotein cholesterol.

MS behandeling: fysieke activiteit

Can Adoption of Regular Exercise Later in Life Prevent Metabolic Risk for Cardiovascular Disease?

Petrella RJ, Lattonzio CN, Demeray A, Varallo V, Blore R.
Diabetes Care, 2005

MS behandeling: fysieke activiteit

- RCT
- N=420 (55-75 jaar)
- Uithoudingstraining, 3x/week, 30-45 min, 75-85% VO₂max
- Inspanningstest:
 - Baseline
 - Jaarlijks gedurende 10 jaar
 - Inclusie: 80% van alle trainingssessies gevolgd (jaarlijks)

(Petrella et al, Diabetes Care, 2005)

MS behandeling: fysieke activiteit

Table 2—Percent change in metabolic indices between 1987 and 1997 for the active and sedentary men and women

| | Active | | | | Sedentary | | | | P |
|----------------------------|------------|------------|--------|-------|-------------|-------------|--------|--------|--------|
| | Baseline | Follow-up | ΔB - F | %Δ | Baseline | Follow-up | ΔB - F | %Δ | |
| BMI (kg/m ²) | 27.3 ± 0.2 | 27.2 ± 0.4 | -0.1 | -0.37 | 27.6 ± 0.4 | 28.9 ± 0.3 | +1.3 | 1.09 | NS |
| BP (mmHg) | 129 ± 7 | 135 ± 5 | +6 | +4.65 | 131 ± 8 | 141 ± 5 | +10 | 7.63 | <0.001 |
| Glucose (mmol/L) | 5.6 ± 1.4 | 5.8 ± 1.2 | +0.2 | +3.57 | 5.6 ± 1.7 | 5.8 ± 1.3 | +0.2 | 3.57 | NS |
| Total cholesterol (mmol/L) | 5.4 ± 1.6 | 5.4 ± 1.4 | +0.1 | -0.06 | 5.3 ± 1.3 | 5.3 ± 1.3 | +0.2 | 3.77 | <0.05 |
| LDL cholesterol (mmol/L) | 2.6 ± 0.7 | 2.7 ± 1.0 | +0.1 | 3.85 | 2.9 ± 0.9 | 3.1 ± 1.2 | +0.2 | 6.89 | <0.02 |
| HDL cholesterol (mmol/L) | 1.1 ± 0.3 | 1.2 ± 0.8 | +0.1 | +9.09 | 1.1 ± 0.3 | 0.9 ± 0.8 | -0.2 | -18.18 | <0.001 |
| Triglycerides (mmol/L) | 2.14 ± 1.1 | 1.96 ± 1.6 | -0.18 | -8.41 | 2.2 ± 1.2 | 2.9 ± 1.4 | +0.7 | 31.82 | <0.001 |
| Insulin (pmol/L) | 276 ± 200 | 273 ± 212 | -3 | -1.09 | 311 ± 234 | 299 ± 230 | -12 | -3.86 | <0.05 |
| HOMA-IR | 6.86 ± 2 | 7.04 ± 0.8 | +0.18 | +6.04 | 7.71 ± 0.40 | 7.74 ± 0.33 | +0.03 | +4.6 | NS |
| Waist circumference (cm) | 92.5 ± 4.5 | 94.5 ± 5.5 | +2 | 2.12 | 90.5 ± 6.3 | 101.3 ± 9.5 | +10.8 | 10.66 | <0.001 |
| METS | 5.7 ± 0.8 | 5.9 ± 0.9 | +0.2 | 3.51 | 5.8 ± 1.0 | 5.0 ± 1.0 | -0.8 | -13.79 | <0.001 |

Data are means ± SD. ΔB - F, absolute baseline minus follow-up; %Δ, percent change from baseline to follow-up.

(Petrella et al, Diabetes Care, 2005)

MS & Lichamelijke Activiteit

- Preventie:
 - Relatie tussen fysieke (in)activiteit en metabool syndroom
- Behandeling
 - Effecten
 - Soort training?
 - Conclusie
- Aanbevelingen

Soort Training?

- Meta-analyses:
 - Bijna uitsluitend Uithoudingstraining

Wat met Krachttraining?

Soort Training?

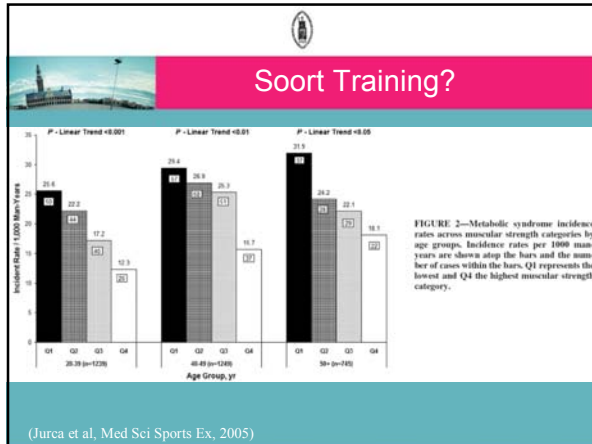
N=3233 (20-80 jaar) ; Follow-up= 6.7±5.2 jaar; Incidentie MS: 480

TABLE 2. Metabolic syndrome incident rates and hazard ratios by muscular strength categories in 3233 men in the Aerobics Center Longitudinal Study (1980–2003).

| | Muscular Strength | | | | P Value for Trend |
|--------------------------------------|-------------------|------------------|------------------|------------------|-------------------|
| | Q1 (Low) | Q2 | Q3 | Q4 (High) | |
| Participants (N) | 808 | 809 | 808 | 808 | |
| Man-years of follow-up | 5129 | 5289 | 5002 | 5085 | |
| Cases (N) | 144 | 130 | 120 | 86 | |
| Age-adjusted rate per 1000 man-years | 28.1 | 24.6 | 21.3 | 15.2 | <0.0001 |
| HR (95% CI), Model 1* | 1.00 | 0.88 (0.69–1.12) | 0.77 (0.60–0.98) | 0.54 (0.42–0.71) | <0.0001 |
| HR (95% CI), Model 2† | 1.00 | 0.95 (0.73–1.21) | 0.89 (0.70–1.13) | 0.66 (0.50–0.88) | 0.004 |
| HR (95% CI), Model 3‡ | 1.00 | 0.96 (0.73–1.21) | 0.93 (0.73–1.18) | 0.76 (0.57–0.99) | 0.06 |

HR, hazard ratio; CI, confidence interval.
* Adjusted for age and examination date.
† Additionally adjusted for smoking, alcohol intake, number of metabolic syndrome risk factors at baseline, and family history of diabetes, hypertension, and premature coronary disease.
‡ Additionally adjusted for maximal treadmill time.

(Jurca et al, Med Sci Sports Ex, 2005)



Soort Training?

Krachttraining als behandeling?

(Braith et al, Circulation, 2006)

| Variable | Aerobic Exercise | Resistance Exercise |
|---------------------------------------|------------------|---------------------|
| Bone mineral density | ↑ | ↑ ↑ ↑ |
| Body composition | | |
| Fat mass | ↓ ↓ | ↓ |
| Muscle mass | ↑ ↑ | ↑ ↑ |
| Strength | ↑ ↑ | ↑ ↑ ↑ |
| Glucose metabolism | | |
| Insulin response to glucose challenge | ↓ ↓ | ↓ ↓ |
| Basal insulin levels | ↓ | ↓ |
| Insulin sensitivity | ↑ ↑ | ↑ ↑ |
| Serum lipids | | |
| High-density lipoprotein | ↑ ↑ | ↑ ↑ |
| Low-density lipoprotein | ↓ ↓ | ↓ ↓ |
| Resting heart rate | ↓ ↓ | ↓ ↓ |
| Blood pressure at rest | | |
| Systolic | ↓ ↓ | ↓ |
| Diastolic | ↓ ↓ | ↓ |
| Physical endurance | ↑ ↑ ↑ | ↑ ↑ |
| Basal metabolism | ↑ | ↑ ↑ |

↑ indicates increased; ↓, decreased; and ↑ ↓, negligible effect.

Soort Training?

Krachttraining als behandeling?

(Williams et al, Circulation, 2007)

| Variable | Aerobic Exercise | Resistance Exercise |
|---|------------------|---------------------|
| Body composition | | |
| Bone mineral density | ↑ ↑ | ↑ ↑ |
| Percent body fat | ↓ ↓ | ↓ |
| Lean body mass | 0 | ↑ ↑ |
| Muscle strength | 0 ↑ | ↑ ↑ ↑ |
| Glucose metabolism | | |
| Insulin response to glucose challenge | ↓ ↓ | ↓ ↓ |
| Basal insulin levels | ↓ | ↓ |
| Insulin sensitivity | ↑ ↑ | ↑ ↑ |
| Plasma lipids and lipoproteins | | |
| HDL cholesterol | ↑ 0 | ↑ 0 |
| LDL cholesterol | ↓ 0 | ↓ 0 |
| Triglycerides | ↓ ↓ | ↓ 0 |
| Cardiovascular dynamics | | |
| Resting heart rate | ↓ ↓ | 0 |
| Stroke volume, resting and maximal | ↑ ↑ | 0 |
| Cardiac output, rest | 0 | 0 |
| Cardiac output, maximal | ↑ ↑ | 0 |
| SBP at rest | ↓ 0 | 0 |
| DBP at rest | ↓ 0 | 0 |
| V _{o2} max | ↑ ↑ ↑ | ↑ 0 |
| Submaximal and maximal endurance time | ↑ ↑ ↑ | ↑ ↑ |
| Submaximal exercise rate-pressure product | ↑ ↑ ↑ | ↑ ↑ |
| Basal metabolic rate | ↑ 0 | ↑ |
| Health-related quality of life | ↑ 0 | ↑ 0 |

Soort Training?

• Krachttraining als Behandeling bij MS: RCT's?

↓

Bij Type 2 diabetici

Krachttraining als behandeling bij Type 2 Diabetici?

Krachttraining additief bij Aerobe training (n=28)

Table 2—Changes in anthropometric, fitness, CT, and glucose disposal measures after 16 weeks

| | Control group | | Ae + RT | | Ae only | |
|--|---------------|--------------|---------------|-------------|--------------|-------------|
| | Absolute | % | Absolute | % | Absolute | % |
| Weight (kg) | 2.0 ± 1.2 | 2.1 ± 1.3 | -2.9 ± 1.3* | 3.2 ± 1.5 | -1.2 ± 0.7* | 1.5 ± 0.8 |
| V _{o2} max (l/min) | -0.05 ± 0.06 | -2.9 ± 3.4 | 0.17 ± 0.06 | 10.2 ± 3.7 | 0.22 ± 0.11 | 13.1 ± 6.5 |
| Glycosylated hemoglobin (%) | -0.03 ± 0.20 | -0.43 ± 0.29 | -0.1 ± 0.22 | -1.4 ± 3.2 | -0.10 ± 0.11 | 1.99 ± 1.74 |
| Glucose infusion rate (mg · kg ⁻¹ · min ⁻¹) | 0.07 ± 0.28 | 3.1 ± 12.2 | 1.82 ± 0.52* | 77.1 ± 22.0 | 0.55 ± 0.36 | 19.8 ± 12.9 |
| CT | | | | | | |
| Total abdominal AT (L4-L5) (cm ²) | 17.1 ± 18.0 | 2.1 ± 2.2 | -48.3 ± 18.4* | -6.7 ± 2.6 | -17.0 ± 10.3 | -2.8 ± 1.7 |
| Subcutaneous (cm ²) | 17.4 ± 9.0 | 3.2 ± 1.6 | -22.0 ± 15.4 | -4.7 ± 3.3 | -8.2 ± 9.7 | -2.0 ± 2.4 |
| Visceral (cm ²) | -0.4 ± 12.0 | -0.15 ± 4.6 | -26.3 ± 7.4 | -10.5 ± 2.9 | -8.8 ± 5.4 | -4.1 ± 2.5 |
| High skeletal muscle | | | | | | |
| Cross-sectional area (cm ²) | 0.7 ± 1.6 | 0.3 ± 0.7 | 5.9 ± 2.0 | 2.8 ± 1.0 | 0.9 ± 2.1 | 0.4 ± 0.9 |
| Low-density muscle (cm ²) | 3.2 ± 1.0 | 6.3 ± 2.0 | -4.1 ± 2.5* | -8.0 ± 4.9 | -1.4 ± 1.3* | 2.8 ± 2.6 |
| Normal-density muscle (cm ²) | -3.5 ± 1.7 | -2.0 ± 1.0 | 10.5 ± 2.0** | 6.7 ± 1.3 | 2.3 ± 1.8* | 1.3 ± 1.0 |

Data are means ± SEM. *Significant change compared with control group (P < 0.05). **Significant change compared with Ae only.

(Cuff et al, Diabetes Care, 2003)

Krachttraining als behandeling bij Type 2 Diabetici?

A Randomized Controlled Trial of Resistance Exercise Training to Improve Glycemic Control in Older Adults With Type 2 Diabetes

Casteneda C, Layne JE, Munoz-Orians L, Gordon PL, Walsmith J, Foldvari M, Roubenoff R, Tucker KL, Nelson ME

Diabetes Care, 25(12):2335-41, 2002

