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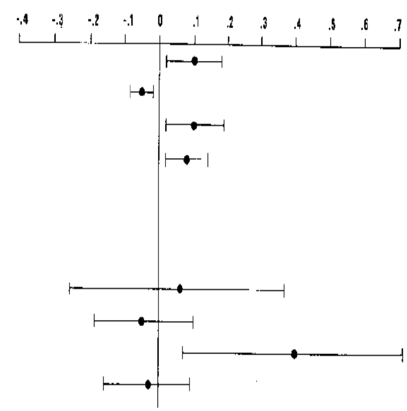
# Effective physical activity and exercise training for control of blood lipids

# Effect of Exercise training on Dyslipidaemia

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

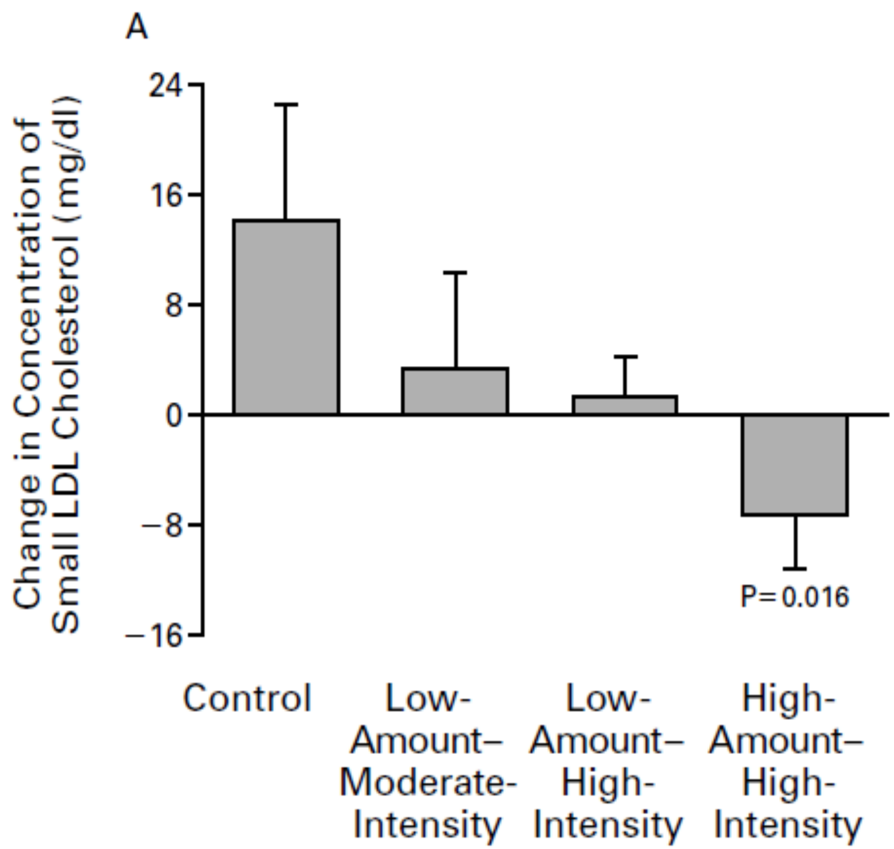
| | *Training group* *n* | *Control group* *n* | *Change in blood lipid*[1] *(mmol/L) (95%CI)* | *WMD*[2] *95% CI Random)* |
|---|---|---|---|---|
| (number of studies = 31) aerobic | | | | |
| TC | 757 | 614 | 0.10 (0.02, 0.18) | |
| HDL-C | 982 | 842 | – 0.05 ( – 0.08, – 0.02) | |
| LDL-C | 843 | 742 | 0.10 (0.02, 0.19) | |
| TG | 907 | 792 | 0.08 (0.02, 0.14) | |
| (number of studies = 4*) resistance | | | | |
| 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) | |

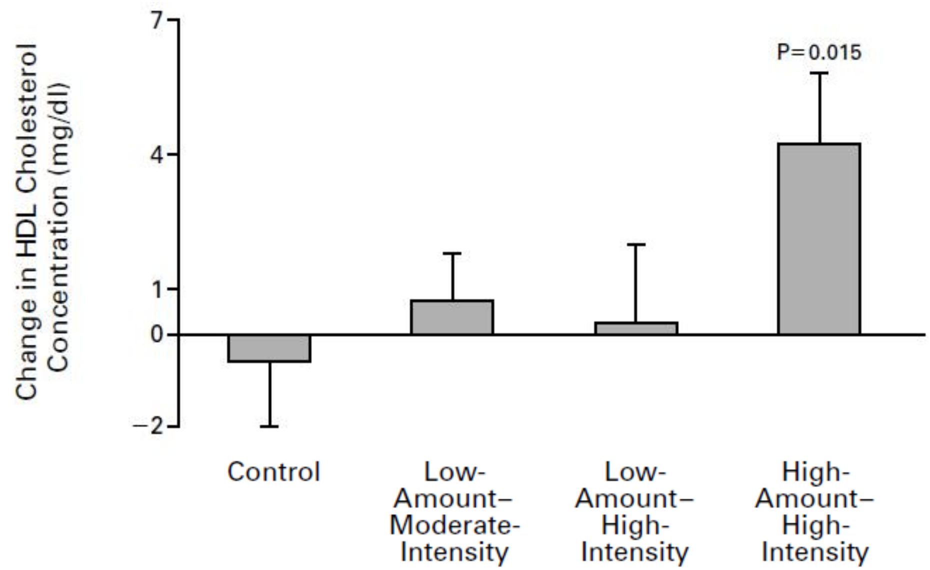



[1]Change expressed as mean change in training Group – mean change in control Group, when change is baseline – final lipid values.
[2]Weighted mean difference (95% CI Random).
* Hersey (1994) included both aerobic and resistance training groups.

Halbert et al. Eur J Clin Nutr 1999

# Effect of three different exercise programs on LDL and HDL




Kraus et al, N Engl J Med 2002;347:1483-92

# Effect of exercise training on Lipid profile: HDL

Multicomponent* VS resistance training

Changes on TG, TC, LDL-C and HDL-C over experimental protocol for both groups.

| | ME ($n = 36$) | | | | RE ($n = 38$) | | | |
|---|---|---|---|---|---|---|---|---|
| | Pre | Post | % Change[a] | $p$ | Pre | Post | % Change[a] | $p$ |
| TG (mg/dl) | 119.3 ± 4.3 | 112.1 ± 4.5 | −5.1 | 0.006 | 113.2 ± 8.1 | 109.4 ± 8.1 | −2.9 | 0.231 |
| TC (mg/dl) | 225.5 ± 4.7 | 225.6 ± 4.7 | 0.7 | 0.988 | 223.1 ± 6.5 | 218.3 ± 6.7 | −1.7 | 0.556 |
| LDL-C (mg/dl) | 152.5 ± 4.4 | 152.4 ± 4.8 | 0.7 | 0.979 | 156.6 ± 5.0 | 154.1 ± 6.5 | −1.5 | 0.609 |
| HDL-C (mg/dl) | 45.4 ± 0.8 | 49.1 ± 0.8 | 9.3 | <0.001 | 46.3 ± 1.6 | 49.1 ± 1.2 | 7.4 | 0.075 |

Values are mean ± S.E. ME: multicomponent exercise; RE: resistance exercise; TG: triglycerides; TC: total cholesterol; LDL-C: low-density lipoprotein cholesterol; HDL-C: high-density lipoprotein cholesterol. $p$ values for pre-training vs. post-training.

[a] [(post-training − pre-training)/pre-training] × 100.

* Multicomponent = endurance and resistance exercises

E. Marquesa, J. Motaa Maturitas. 2009 Apr 6.

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# Effective physical activity and exercise training for control of blood lipids

*Mini summary*

It has not yet been established how much exercise is required in order to improve the lipid pattern and, more generally, to reduce cardiovascular risk. The data currently available seem to indicate that a moderately intense aerobic exercise programme is sufficient to improve TG and HDL-C, while a more demanding regimen does not offer further significant advantages. It seems that the amount of exercise, in terms of overall energy expenditure, is of greater importance than the intensity of training. A threshold value of about 1000 kcal/week has been identified as the energy expenditure required in order to achieve a significant increase in HDL-C. Moderate PA involving energy expenditure greater than 1000 kcal/week, and carried out at intensity equal to 75–85% of the $HR_{max}$ would therefore prove efficacious, safe, and easily practicable for the majority of individuals. Recent data, however, seem to suggest that high-intensity aerobic interval training could increase HDL-C more than moderate-intensity continuous training in patients with metabolic syndrome. Exercise training should be scheduled in 3–4 sessions/week of at least 20 min each and should involve aerobic activity, such as brisk walking, jogging, or cycling. Moderate-intensity resistance exercise can efficaciously be combined with this in order to improve musculoskeletal efficiency and to increase lean body mass.

Vanhees et al, EJPC, 19(5):1005-1033

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# Effective physical activity and exercise training for control of blood pressure and arterial compliance

**Table 4.** Minimum exercise prescription recommendations in the prevention and management of hypertension

| Mode | Intensity | Duration | Frequency |
|---|---|---|---|
| Aerobic (endurance) (walking, cycling, jogging, running) | Moderate: 40–60% of HRR or 12–13 RPE | 30 min | 5 days/week |
| | OR | | |
| | Vigorous: 60–84% of HRR or 14–16 RPE | 20 min | 3 days/week |
| | AND | | |
| Resistance (strength) (progressive weight training using major muscles, bodyweight exercise, theraband exercise) | 8–12 repetitions resulting in substantial fatigue | One set of 8–10 exercises (multiple sets if time allows) | 2 or more non-consecutive days/week |

HRR, heart rate reserve derived from individual maximal exercise testing; RPE, Borg rating of perceived exertion (6–20 scale). Combinations of moderate- and vigorous-intensity aerobic activity can be performed to meet the weekly recommendations (e.g. 2 × 30 min moderate sessions and 2 × 20 min vigorous sessions). Adapted from Sharman & Stowasser.[196]

Vanhees et al, EJPC, 19(5):1005-1033

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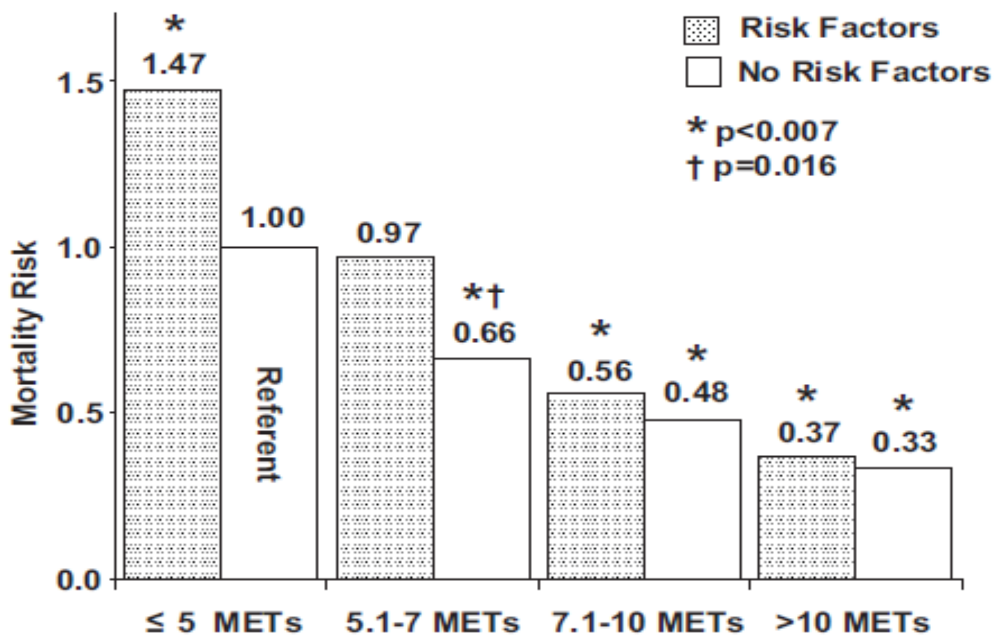
# Effective physical activity and exercise training for control of blood pressure and arterial compliance

# Exercise Capacity and Mortality in Hypertensive Men With and Without Additional Risk Factors




* Different from the very-low-fit (≤ 5 METs) with no risk factors

† Different from the low-fit (5.1 to 7 METs) with risk factors

**Figure.** Mortality risk within each fitness category for hypertensive individuals with and without additional risk factors.

Kokkinos P. et al., Am Heart J. 2009

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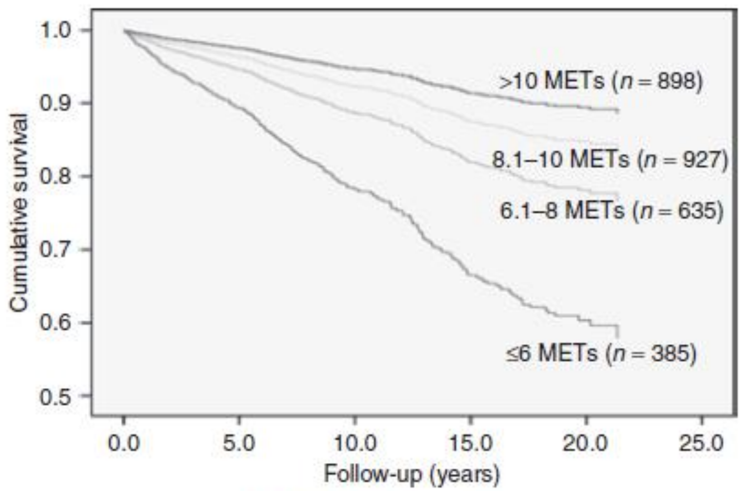
# Exercise Capacity and All-Cause Mortality in Prehypertensive Men

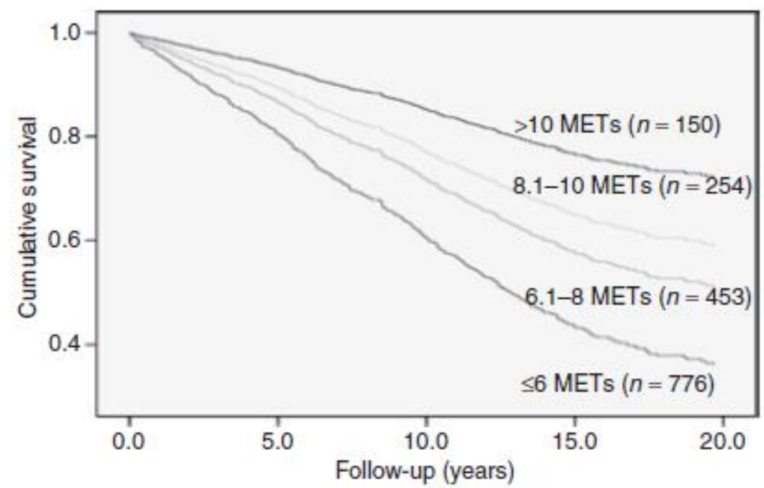
Cumulative survival for individuals ≤60 years of age




Number of remaining cases

| | | | | | | |
|---|---|---|---|---|---|---|
| >10 | METs | 898 | 609 | 323 | 118 | 41 |
| 8.1–10 | METs | 927 | 634 | 342 | 191 | 60 |
| 6.1–8 | METs | 635 | 459 | 254 | 160 | 42 |
| <6 | METs | 385 | 274 | 169 | 104 | 30 |

Cumulative survival for individuals >60 years of age




Number of remaining cases

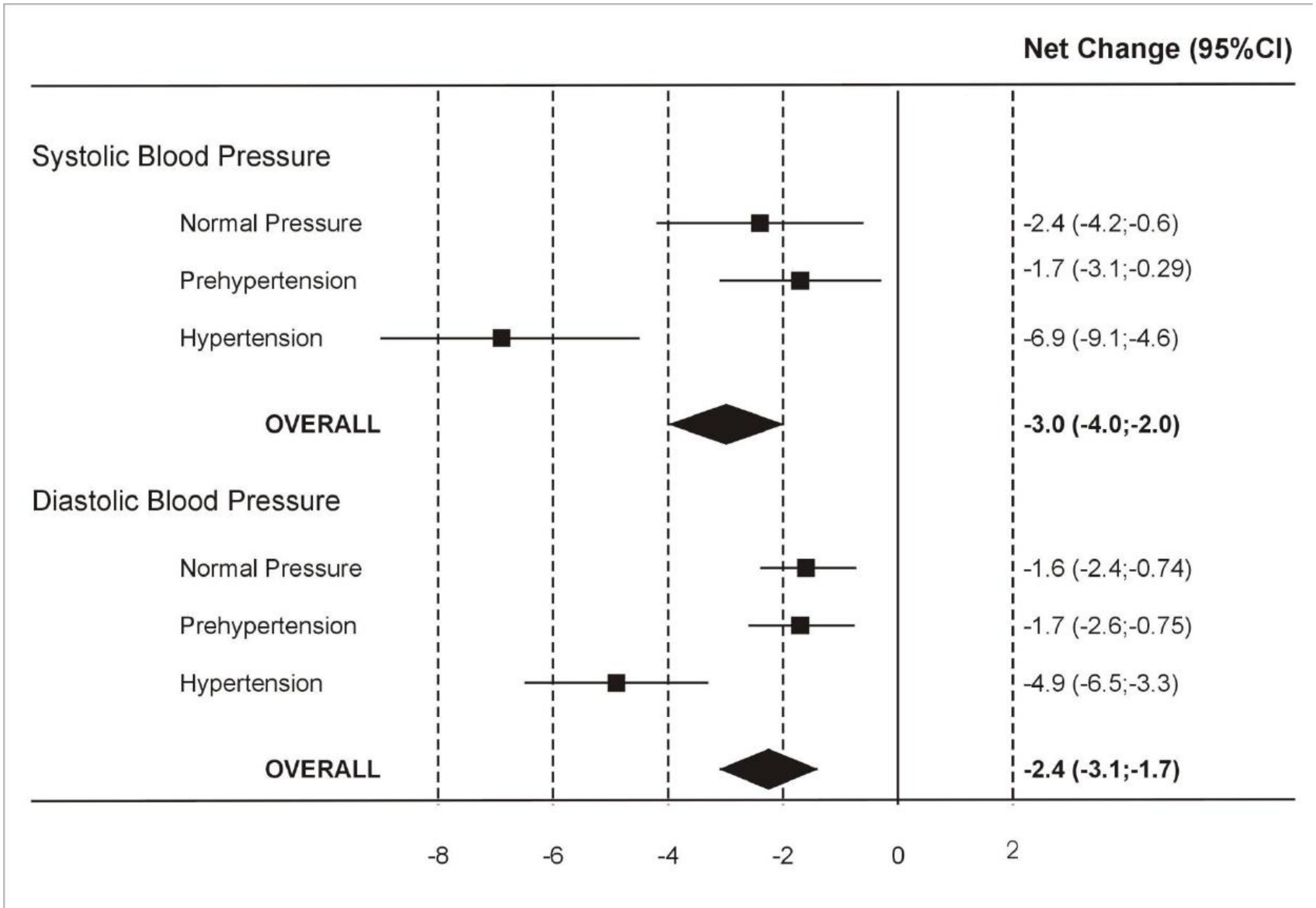
| | | | | | |
|---|---|---|---|---|---|
| >10 | METs | 150 | 100 | 59 | 15 |
| 8.1–10 | METs | 254 | 182 | 107 | 40 |
| 6.1–8 | METs | 453 | 332 | 173 | 89 |
| <6 | METs | 776 | 529 | 298 | 171 |

- A strong, inverse and graded association between exercise capacity and all-cause mortality.
- More protective effects of increased fitness in younger individuals
  → age should be more closely considered when assessing fitness and mortality relationships.

Kokkinos P. et al., Am J Hypertens. 2009

# Net-training induced changes in BP after dynamic aerobic endurance training.

Meta-analysis by Cornelissen et al. Hypertension 2005



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# THE IMPACT OF DYNAMIC RESISTANCE TRAINING ON BLOOD PRESSURE AND OTHER CARDIOVASCULAR RISK FACTORS: A META-ANALYSIS OF RANDOMIZED CONTROLLED TRIALS

Cornelissen V, Fagard R, Coeckelberghs E, Vanhees L. Hypertens 2011; 66(4): 1577-85

# Systolic Blood Pressure

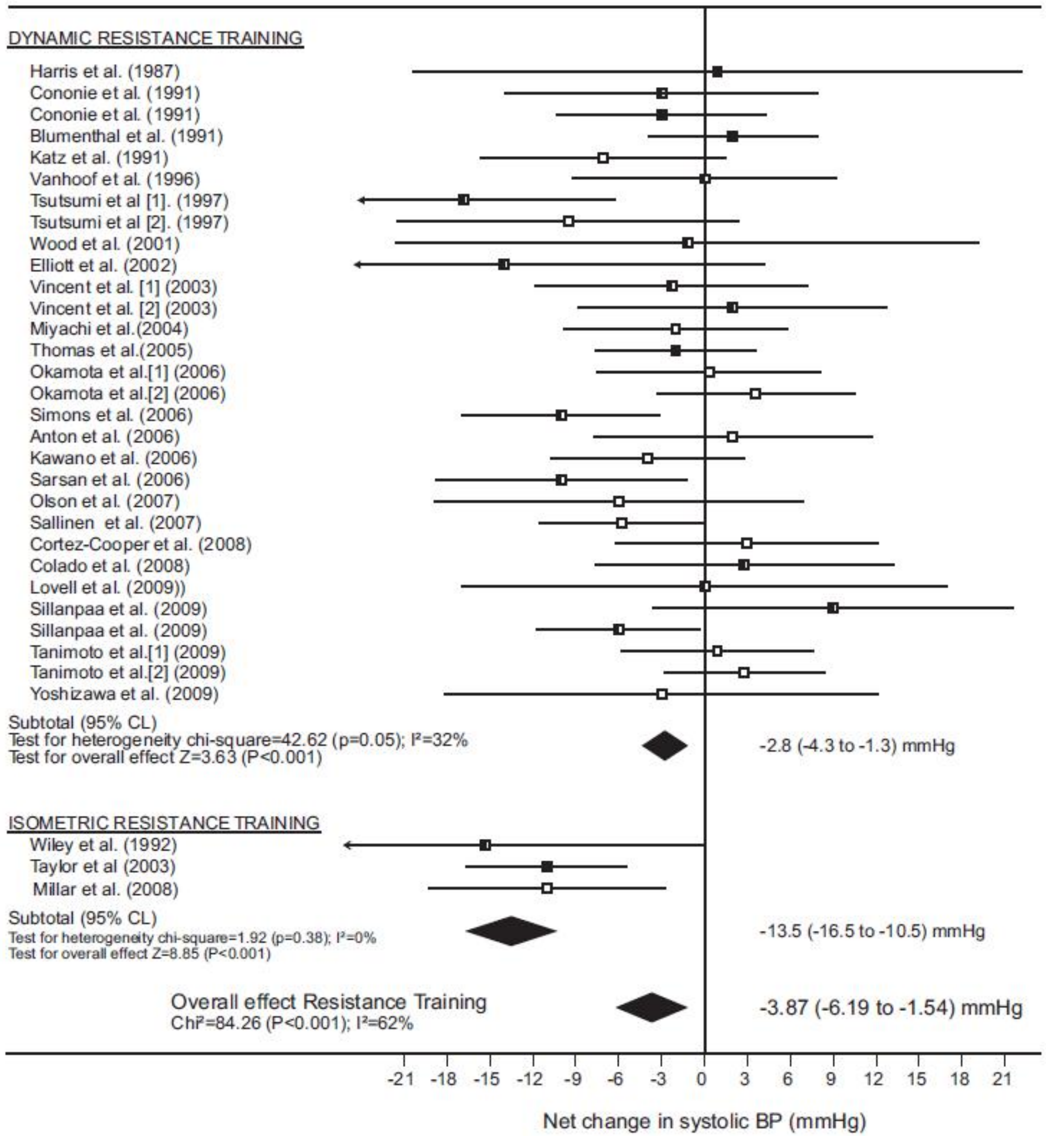


**Figure 1.** Average net changes in systolic blood pressure and corresponding 95% confidence limits in 28 randomized, controlled trials involving 33 study groups. The overall effect represents a pooled estimate obtained by summing the average net change for each trial, weighted by the inverse of its variance. Open squares represent optimal blood pressure study groups; half-closed squares represent prehypertensive study groups; closed squares represent hypertensive study groups.

Cornelissen V, Fagard R, Coeckelberghs E, Vanhees L. Hypertens 2011; 66(4): 1577-85

# Diastolic Blood Pressure

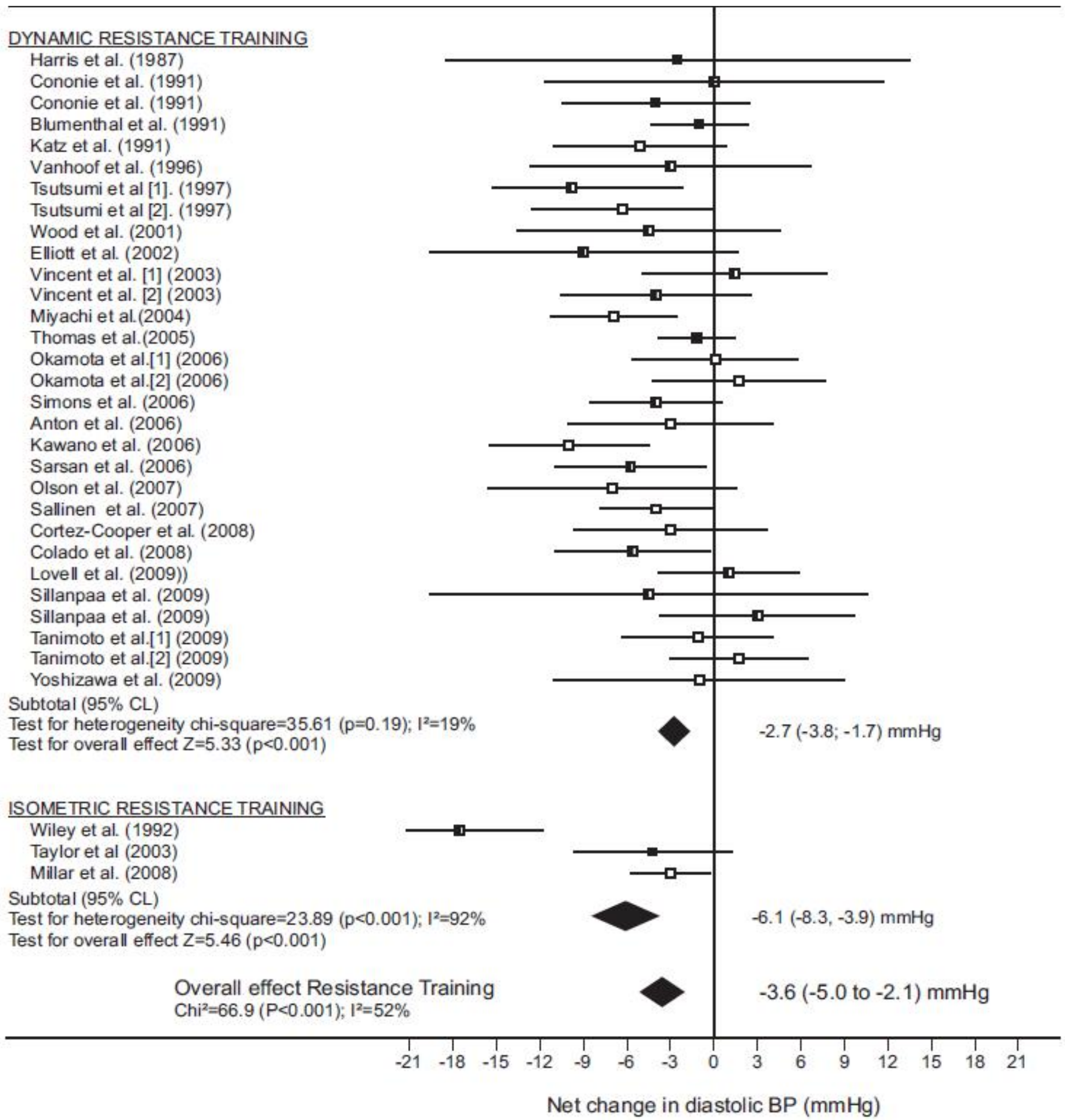


**Figure 2.** Average net changes in diastolic blood pressure and corresponding 95% confidence limits in 28 randomized controlled trials involving 33 study groups. The overall effect represents a pooled estimate obtained by summing the average net change for each trial, weighted by the inverse of its variance. Open squares represent optimal blood pressure study groups; half-closed squares represent prehypertensive study groups; closed squares represent hypertensive study groups.

Cornelissen V, Fagard R, Coeckelberghs E, Vanhees L. Hypertens 2011; 66(4): 1577-85

# Comparison of Cardioprotective Benefits of Vigorous Versus Moderate Intensity Aerobic Exercise: effect of exercise intensity on blood pressure

Clinical trials of exercise intensity and blood pressure with total work equated between groups

| Study | Age (yrs)/Sex | Study Length | Training Intensity | No. per Group | Change in $VO_2max$ | Change in Blood Pressure |
|---|---|---|---|---|---|---|
| Asikainen et al[20] | Postmenopausal F | 24 wks | 65% $VO_2max$ | 87 | ↑ | ↓ diastolic BP |
| | | | 55% $VO_2max$ | 20 | ↑ | No effect |
| | | | 45% $VO_2max$ | 21 | ↑ | No effect |
| Braith et al[21] | 60–79 M&F | 3 mo | 85% HRR | 14 | ↑ ↑ | ↓ systolic and diastolic BP |
| | | | 70% HRR | 19 | ↑ | ↓ systolic and diastolic BP |
| Kang et al[22] | 13–16 M&F | 8 mo | 77% $VO_2max$ | 20 | ↑ | ↓ diastolic BP |
| | | | 57% $VO_2max$ | 21 | No effect | No effect |
| Tashiro et al[23] | 33–57 M&F* | 10 wks | 75% $VO_2max$ | 8 | Not reported | ↓ systolic and diastolic BP |
| | | | 50% $VO_2max$ | 8 | | ↓ systolic BP only |

* Subjects in Tashiro et al[23] were initially hypertensive.
HRR = heart rate reserve; other abbreviations as in Table 2.

Swain and Franklin; Am J Cardiol, 2006

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# Effective physical activity and exercise training for control of blood pressure and arterial compliance

Table 4. Minimum exercise prescription recommendations in the prevention and management of hypertension

| Mode | Intensity | Duration | Frequency |
| --- | --- | --- | --- |
| Aerobic (endurance) (walking, cycling, jogging, running) | Moderate: 40–60% of HRR or 12–13 RPE | 30 min | 5 days/week |
| | OR | | |
| | Vigorous: 60–84% of HRR or 14–16 RPE | 20 min | 3 days/week |
| | AND | | |
| Resistance (strength) (progressive weight training using major muscles, bodyweight exercise, theraband exercise) | 8–12 repetitions resulting in substantial fatigue | One set of 8–10 exercises (multiple sets if time allows) | 2 or more non-consecutive days/week |

HRR, heart rate reserve derived from individual maximal exercise testing; RPE, Borg rating of perceived exertion (6–20 scale). Combinations of moderate- and vigorous-intensity aerobic activity can be performed to meet the weekly recommendations (e.g. 2 × 30 min moderate sessions and 2 × 20 min vigorous sessions). Adapted from Sharman & Stowasser.[196]

Vanhees et al, EJPC, 19(5):1005-1033

# Effects of different kinds of physical activity and exercise training

## On Cardiovascular Risk Factors

1. Blood Lipids
2. Insuline / Blood Glucose
3. Obesity / Weight
4. Blood Pressure
5. Multiple Risk Factors

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Sports Med (2013) 43:121–133
DOI 10.1007/s40279-012-0003-z

SYSTEMATIC REVIEW

# The Effect of Exercise on the Cardiovascular Risk Factors Constituting the Metabolic Syndrome

## A Meta-Analysis of Controlled Trials

Nele Pattyn · Véronique A. Cornelissen ·
Saeed R. Toghi Eshghi · Luc Vanhees

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# Metabolic syndrome – Waist circumference



| Study or Subgroup | Mean Difference IV, Fixed, 95% CI | Year |
|---|---|---|
| Dumortier et al. [14] | −7.60 [−20.03, 4.83] | 2003 |
| Gomes et al. [16] | 3.00 [−3.56, 9.56] | 2008 |
| Irving et al. [17] A | 0.60 [−11.10, 12.30] | 2008 |
| Irving et al. [17] B | 5.10 [−5.84, 16.04] | 2008 |
| Tjønna et al. [18] A | −11.50 [−22.89, −0.11] | 2008 |
| Tjønna et al. [18] B | −12.90 [−26.90, 1.10] | 2008 |
| Stensvold et al. [21] | −2.10 [−10.53, 6.33] | 2010 |
| Balducci et al. [20] | −3.70 [−5.36, −2.04] | 2010 |
| Total (95% CI) | −3.36 [−4.87, −1.84] | |

Heterogeneity: $\chi^2 = 10.78$, df = 7 ($p = 0.15$); $I^2 = 35\%$
Test for overall effect: $Z = 4.35$ ($p < 0.0001$)

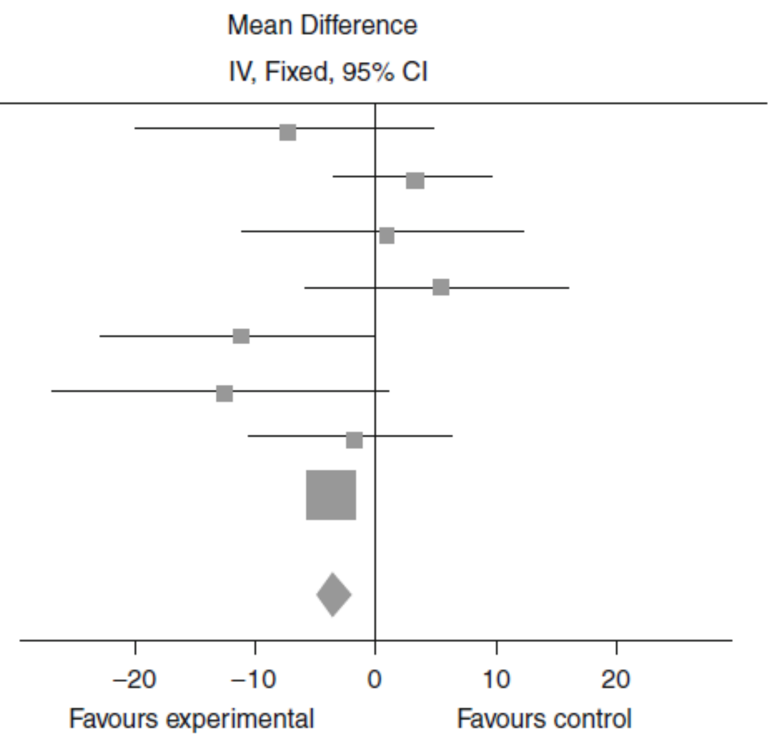


**Fig. 2** Average net changes and corresponding 95% confidence intervals for waist circumference. Tjønna et al. [18] *A* and *B* represents moderate continuous training programme and aerobic interval training programme, respectively; and Irving et al. [17] *A* and *B* represents high-intensity training and low-intensity training, respectively. *CI* confidence intervals, *df* degrees of freedom, *IV* intervention, $\chi^2$ Chi-squared

Pattyn et al, Sports Med (2013), 43:121-132

# Metabolic syndrome – SBP

| Study or Subgroup | Mean Difference IV, Fixed, 95% CI | Year |
|---|---|---|
| Watkins et al. [15] | −5.00 [−14.60, 4.60] | 2003 |
| Gomes et al. [16] | −3.00 [−9.56, 3.56] | 2008 |
| Irving et al. [17] A | −7.00 [−21.57, 7.57] | 2008 |
| Irving et al. [17] B | −6.00 [−19.78, 7.78] | 2008 |
| Tjønna et al. [18] A | −6.00 [−22.40, 10.40] | 2008 |
| Tjønna et al. [18] B | −20.00 [−37.67, −2.33] | 2008 |
| Stensvold et al. [21] | −7.90 [−24.43, 8.63] | 2010 |
| Balducci et al. [20] | −7.50 [−9.66, −5.34] | 2010 |
| Total (95% CI) | −7.11 [−9.03, −5.18] | |

Heterogeneity: $\chi^2 = 3.91$, df = 7 ($p = 0.79$); $I^2 = 0\%$
Test for overall effect: $Z = 7.23$ ($p < 0.00001$)

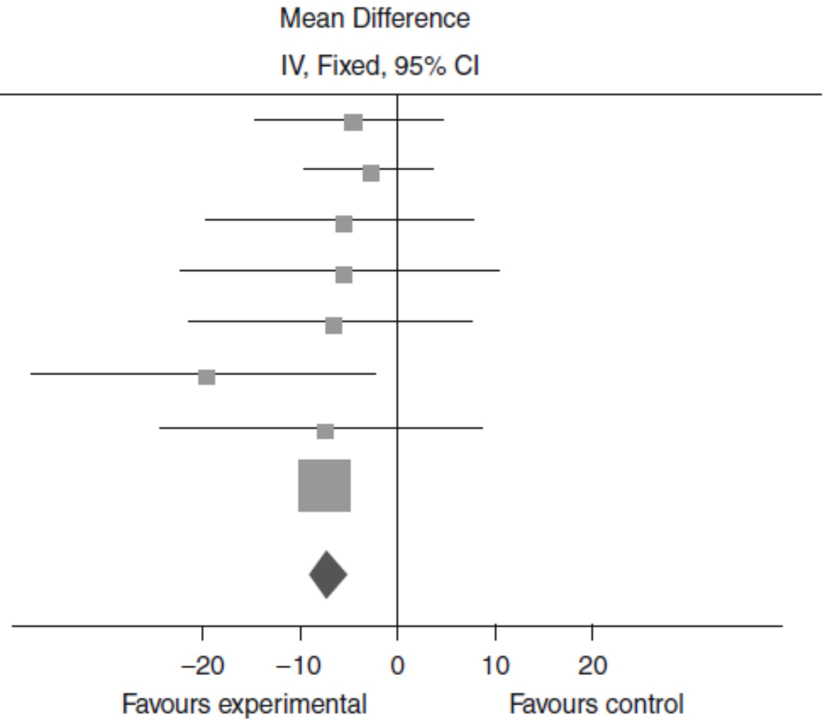


**Fig. 3** Average net changes and corresponding 95% confidence intervals for systolic blood pressure. Tjønna et al. [18] *A* and *B* represents moderate continuous training programme and aerobic interval training programme, respectively; and Irving et al. [17] *A* and *B* represents high-intensity training and low-intensity training, respectively. *CI* confidence intervals, *df* degrees of freedom, *IV* intervention, $\chi^2$ Chi-squared

Pattyn et al, Sports Med (2013), 43:121-132

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# Metabolic syndrome – DBP

| Study or Subgroup | Mean Difference IV, Fixed, 95% CI | Year |
|---|---|---|
| Watkins et al. [15] | −4.00 [−8.90, 0.90] | 2003 |
| Gomes et al. [16] | 1.00 [−4.61, 6.61] | 2008 |
| Irving et al. [17] A | −2.00 [−10.62, 6.62] | 2008 |
| Irving et al. [17] B | 2.00 [−7.88, 11.88] | 2008 |
| Tjønna et al. [18] A | −7.00 [−19.05, 5.05] | 2008 |
| Tjønna et al. [18] B | −14.00 [−26.89, −1.11] | 2008 |
| Stensvold et al. [21] | −4.50 [−13.53, 4.53] | 2010 |
| Balducci et al. [20] | −5.50 [−6.58, −4.42] | 2010 |
| Total (95% CI) | −5.15 [−6.16, −4.13] | |

Heterogeneity: $\chi^2 = 9.67$, df = 7 ($p = 0.21$); $I^2 = 28\%$
Test for overall effect: $Z = 9.96$ ($p < 0.00001$)

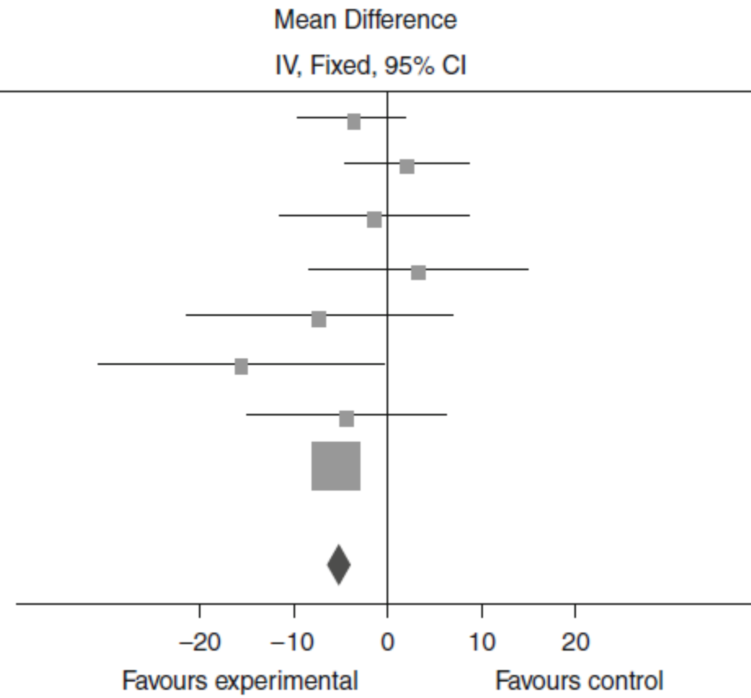


**Fig. 4** Average net changes and corresponding 95% confidence intervals for diastolic blood pressure. Tjønna et al. [18] *A* and *B* represents moderate continuous training programme and aerobic interval training programme, respectively; and Irving et al. [17] *A* and *B* represents high-intensity training and low-intensity training, respectively. *CI* confidence intervals, *df* degrees of freedom, *IV* intervention, $\chi^2$ Chi-squared

Pattyn et al, Sports Med (2013), 43:121-132

# Metabolic syndrome – HDL

| Study or Subgroup | Mean Difference IV, Fixed, 95% CI | Year |
|---|---|---|
| Dumortier et al. [14] | 0.31 [−0.01, 0.63] | 2003 |
| Watkins et al. [15] | 0.03 [−0.23, 0.29] | 2003 |
| Gomes et al. [16] | −0.07 [−0.17, 0.03] | 2008 |
| Irving et al. [17] A | 0.17 [−0.11, 0.45] | 2008 |
| Irving et al. [17] B | 0.09 [−0.22, 0.40] | 2008 |
| Tjønna et al. [18] A | 0.26 [−0.03, 0.55] | 2008 |
| Tjønna et al. [18] B | 0.22 [−0.06, 0.50] | 2008 |
| Stensvold et al. [21] | −0.04 [−0.50, 0.42] | 2010 |
| Balducci et al. [20] | 0.07 [0.04, 0.10] | 2010 |
| Total (95% CI) | 0.06 [0.03, 0.09] | |

Heterogeneity: $\chi^2 = 13.00$, df = 8 ($p = 0.11$); $I^2 = 38\%$
Test for overall effect: $Z = 4.27$ ($p < 0.0001$)

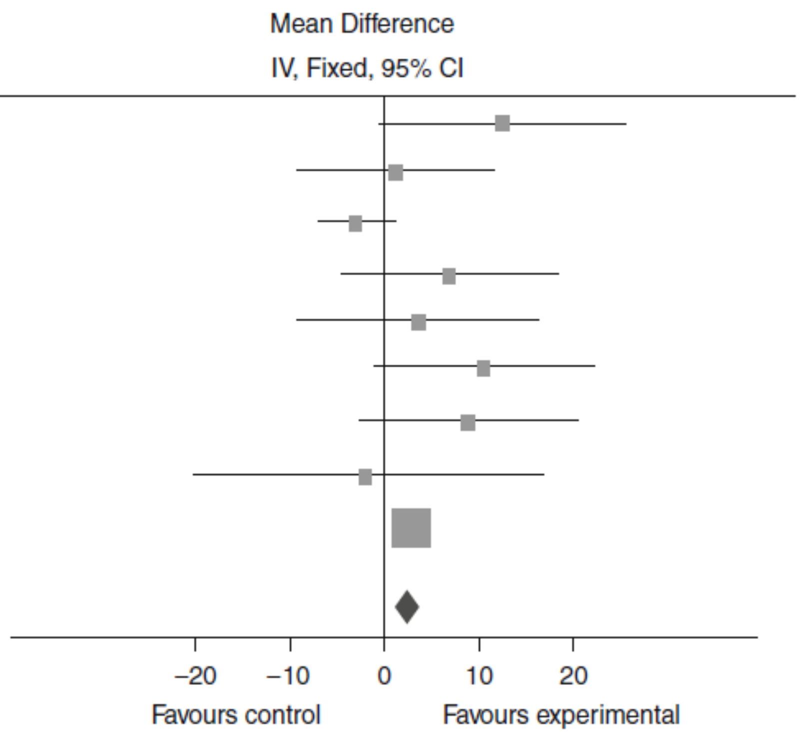


**Fig. 5** Average net changes and corresponding 95% confidence intervals for HDL-C. Tjønna et al. [18] *A* and *B* represents moderate continuous training programme and aerobic interval training programme, respectively; and Irving et al. [17] *A* and *B* represents high-intensity training and low-intensity training, respectively. *CI* confidence intervals, *df* degrees of freedom, *IV* intervention, $\chi^2$ Chi-squared

Pattyn et al, Sports Med (2013), 43:121-132

# Metabolic syndrome – plasma Glucose

| Study or Subgroup | Mean Difference IV, Fixed, 95% CI | Year |
|---|---|---|
| Dumortier et al. [14] | −1.59 [−3.25, 0.07] | 2003 |
| Watkins et al. [15] | −0.29 [−0.74, 0.16] | 2003 |
| Gomes et al. [16] | −0.33 [−1.18, 0.52] | 2008 |
| Irving et al. [17] A | 0.19 [−1.11, 1.49] | 2008 |
| Irving et al. [17] B | −0.36 [−1.46, 0.74] | 2008 |
| Tjønna et al. [18] A | −0.20 [−1.62, 1.22] | 2008 |
| Tjønna et al. [18] B | −0.30 [−1.77, 1.17] | 2008 |
| Stensvold et al. [21] | −0.20 [−1.70, 1.30] | 2010 |
| Total (95% CI) | −0.31 [−0.64, 0.01] | |

Heterogeneity: $\chi^2 = 2.92$, df = 7 ($p = 0.89$); $I^2 = 0\%$
Test for overall effect: $Z = 1.90$ ($p = 0.06$)

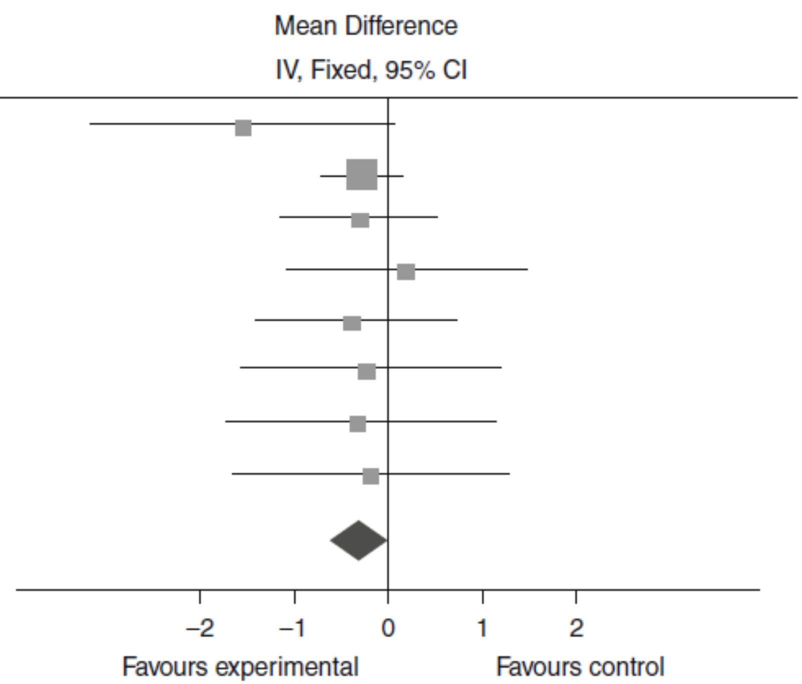


**Fig. 7** Average net changes and corresponding 95% confidence intervals for plasma glucose. Tjønna et al. [18] *A* and *B* represents moderate continuous training programme and aerobic interval training programme, respectively; and Irving et al. [17] *A* and *B* represents high-intensity training and low-intensity training, respectively. *CI* confidence intervals, *df* degrees of freedom, *IV* intervention, $\chi^2$ Chi-squared

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Original Scientific Paper

# Physical fitness matters more than physical activity in controlling cardiovascular disease risk factors

Barbara Sassen[a], Véronique A. Cornelissen[c], Henri Kiers[a], Harriet Wittink[a], Gerjo Kok[b] and Luc Vanhees[a,d]

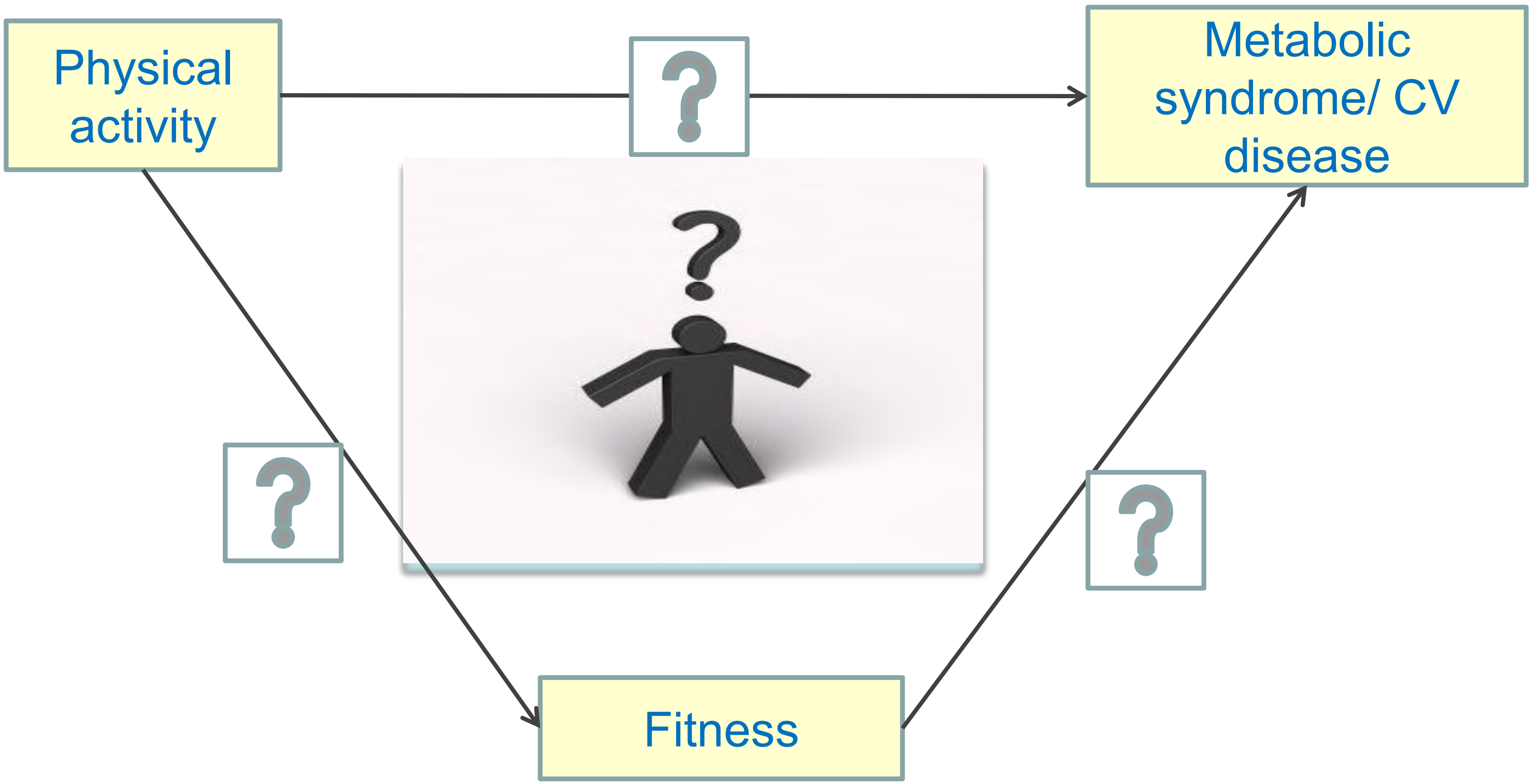
[a]Department of Health and Lifestyle, University of Applied Sciences, Utrecht, [b]Department of Applied Psychology, Maastricht University, Maastricht, The Netherlands, [c]Department of Cardiovascular Diseases and [d]Department of Rehabilitation Sciences, K.U. Leuven, Leuven, Belgium

**Received** 14 May 2009 **Accepted** 24 July 2009

**European Journal of Cardiovascular Prevention and Rehabilitation** 2009, 16:677–683

# Physical fitness matters more than physical activity in controlling cardiovascular disease risk factors.

Improving outcomes with exercise: fitness or risk factors?




B. Sassen, V. Cornelissen, H. Kiers, H.Wittink, G. Kok, L. Vanhees , EJCPR, 2009.

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HOGESCHOOL UTRECHT

# Physical fitness matters more than physical activity in controlling cardiovascular disease risk factors

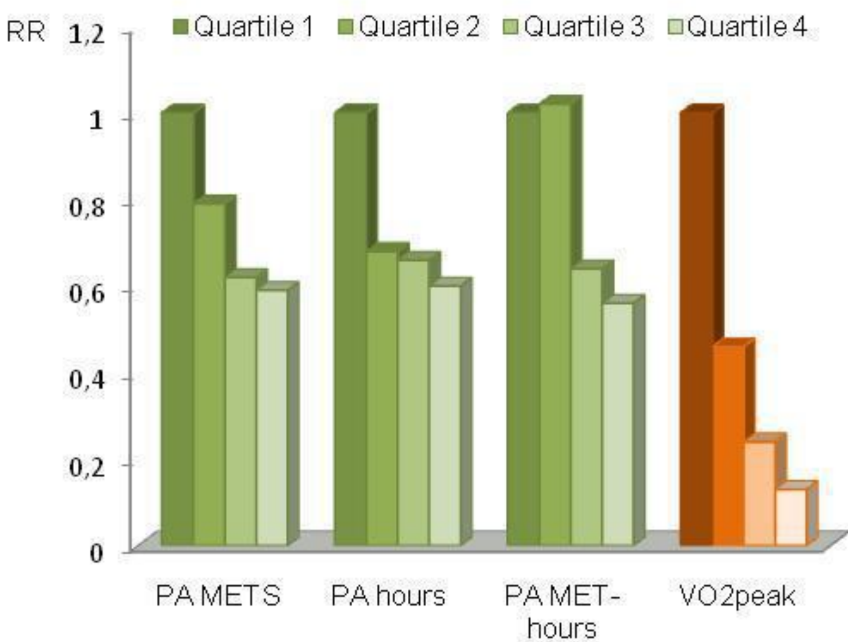
Sassen et al, 2009

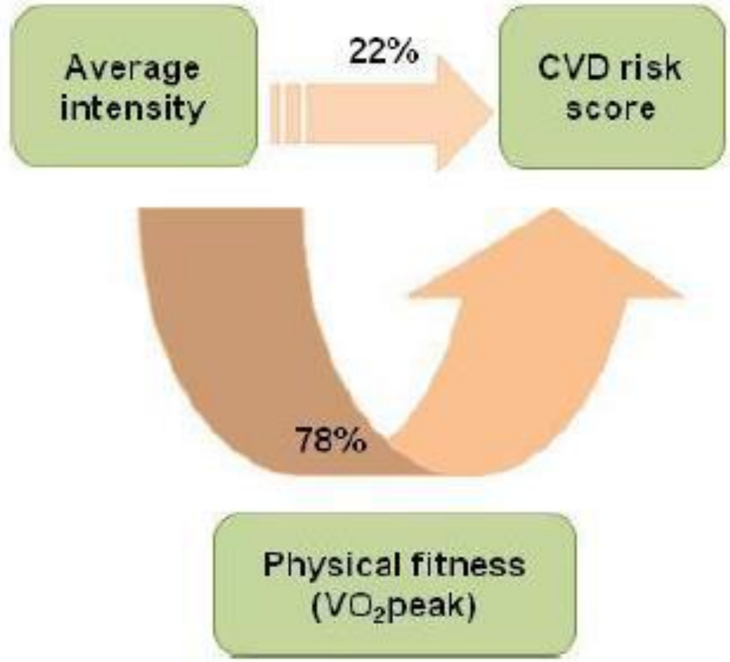
**Table 1** Characteristics of 1298 police employees according to the number of CVD risk factors present

| | 0–1 risk factor | 2 risk factors | ≥ 3 risk factors | *P* value |
|---|---|---|---|---|
| Prevalence | 751 (57.9) | 305 (23.5) | 242 (18.6) | |
| Sex (% male) | 60.7 | 72.4 | 81.4 | <0.001 |
| Age (years) | 35.5 ± 10.7 | 39.7 ± 10.8[a] | 44.8 ± 9.4[a,b] | <0.001 |
| Smoking habits present | 150 (20.0) | 82 (26.9) | 65(26.9) | <0.01 |
| Smoking habits past | 229 (30.5) | 83 (27.2) | 85 (35.1) | <0.01 |
| Weight (kg) | 75.4 ± 12.1 | 83.5 ± 11.7[a] | 91.5 ± 13.4[a,b] | <0.001 |
| Peak $VO_2$ (ml/kg/min) | 37.5 ± 7.6 | 34.4 ± 8.1[a] | 31.0 ± 7.5[a,b] | <0.001 |
| Sedentary % of value | 110.3 ± 19.1 | 107.4 ± 18.6 | 102.9 ± 19.3[a,b] | <0.001 |
| RER ($VCO_2/VO_2$) | 1.07 ± 0.07 | 1.06 ± 0.08 | 1.05 ± 0.07[a] | <0.01 |
| Peak heart rate (bpm) | 171.8 ± 13.2 | 167.0 ± 15.4[a] | 164.4 ± 16.3[a] | <0.001 |
| Borg score | 15.6 ± 1.4 | 15.6 ± 1.4 | 15.5 ± 1.6 | NS |
| PA METs | 4.9 ± 1.4 | 4.6 ± 1.5[a] | 4.3 ± 1.5[a,b] | <0.01 |
| PA hours | 9.6 ± 8.7 | 9.3 ± 9.0 | 8.1 ± 8.4 | NS |
| PA MET-hours | 47.4 ± 43.8 | 44.9 ± 45.9 | 37.6 ± 38.6[a] | <0.01 |
| PA MET-hours high | 15.4 ± 21.6 | 14.1 ± 28.3 | 7.8 ± 15.3[a,b] | <0.001 |
| PA MET-hours moderate | 20.5 ± 25.6 | 18.5 ± 24.3 | 18.9 ± 25.1 | NS |
| PA MET-hours low | 11.4 ± 18.6 | 12.3 ± 16.7 | 10.8 ± 16.1 | NS |

Values are numbers (%) or mean ± SD. CVD, cardiovascular disease; METs, metabolic equivalent values; NS, not significant; PA, physical activity; PA hours, duration of PA in hours/week; PA METs, average intensity of PA in METs; PA MET-hours, total volume of PA in METs × hours/week; PA MET-hours high, PA MET-hours divided by level of intensity >6 METs × hours/week; PA MET-hours low; PA MET-hours divided by level of intensity low, <4 METs × hours/week; PA MET-hours moderate, PA MET-hours divided by level of intensity 4–6 METs × hours/week; peak $VO_2$, peak volume of oxygen consumption (ml/kg/min); RER, respiratory exchange ratio; $VCO_2$, carbon dioxide output. [a]Different from 0–1 risk factor group. [b]Different from 2 risk factors group.

# Physical fitness matters more than physical activity incontrolling cardiovascular disease risk factors




Left figure: adjusted (age and gender) odds ratios for having the metabolic syndrome in different categories of physical activity and in the categories of physical fitness . Quartile 1 corresponds to the lowest category. P-value for trend < 0.05 for all. Right figure: pathway of the relation between physical activity and CVD risk score through physical fitness.

Sassen et al, 2009

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# Recommendations from the EACPR: Part III

European Journal of Preventive Cardiology

*Review*

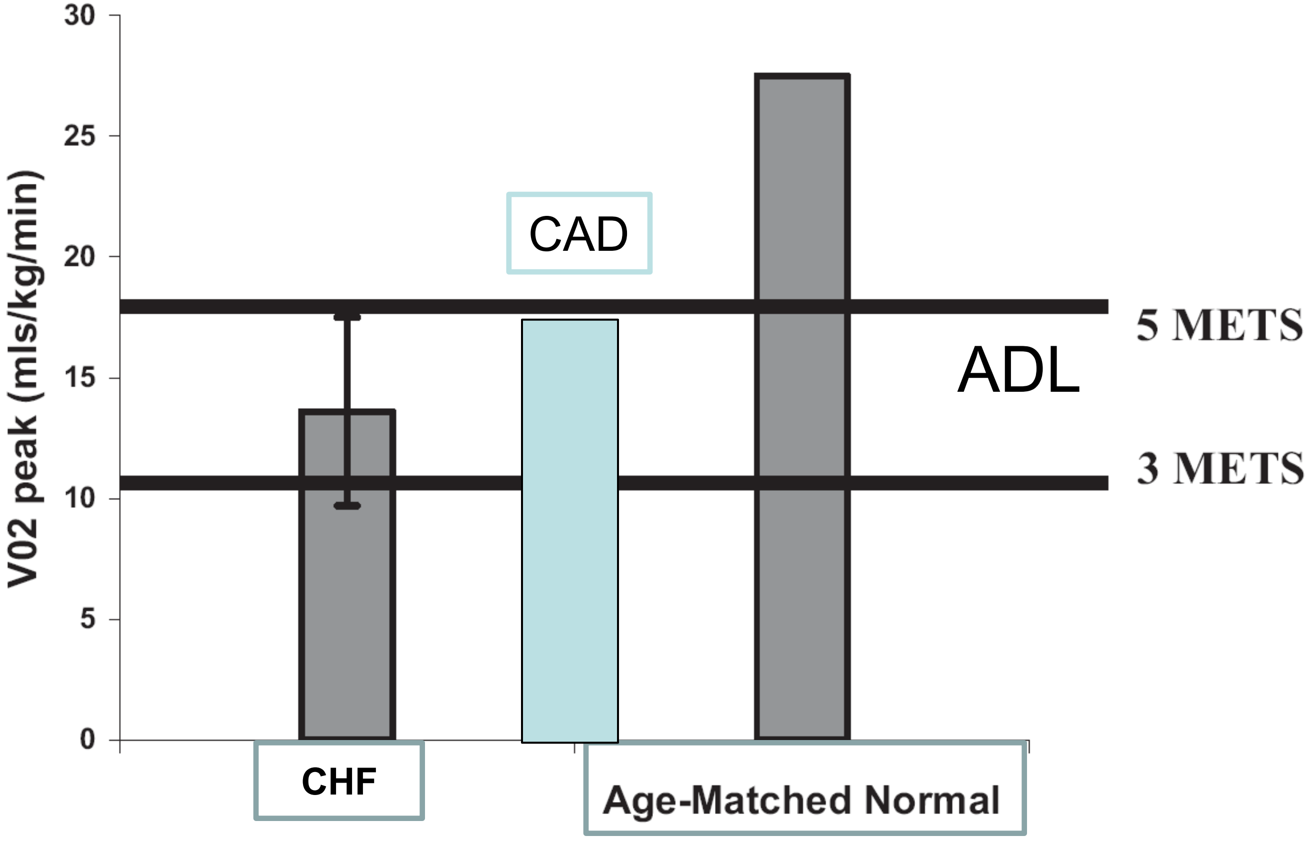
European Journal of Preventive Cardiology
19(6) 1333–1356

DOI: 10.1177/2047487312437063
ejpc.sagepub.com
SAGE

## Importance of characteristics and modalities of physical activity and exercise in the management of cardiovascular health in individuals with cardiovascular disease (Part III)

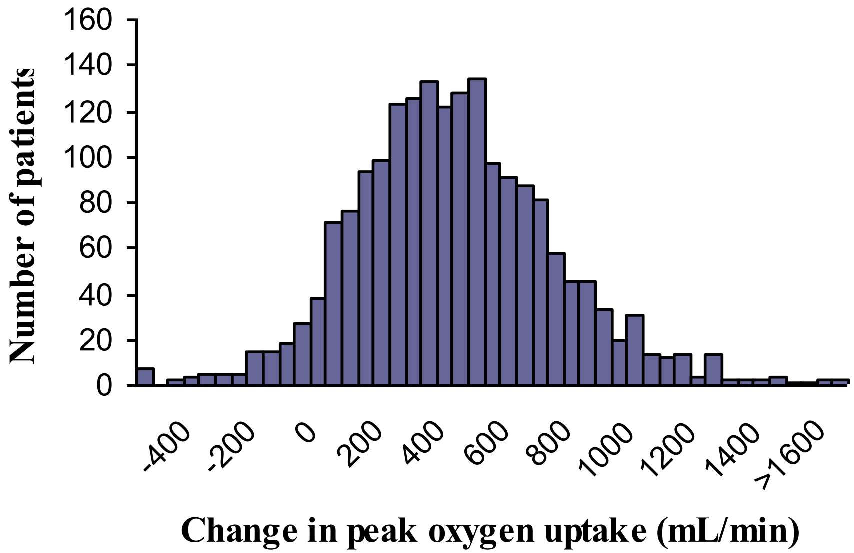
L Vanhees[1], B Rauch[2], M Piepoli[3], F van Buuren[4], T Takken[5], M Börjesson[6], B Bjarnason-Wehrens[7], P Doherty[8], D Dugmore[9] and M Halle[10] (on behalf of the writing group of the EACPR)

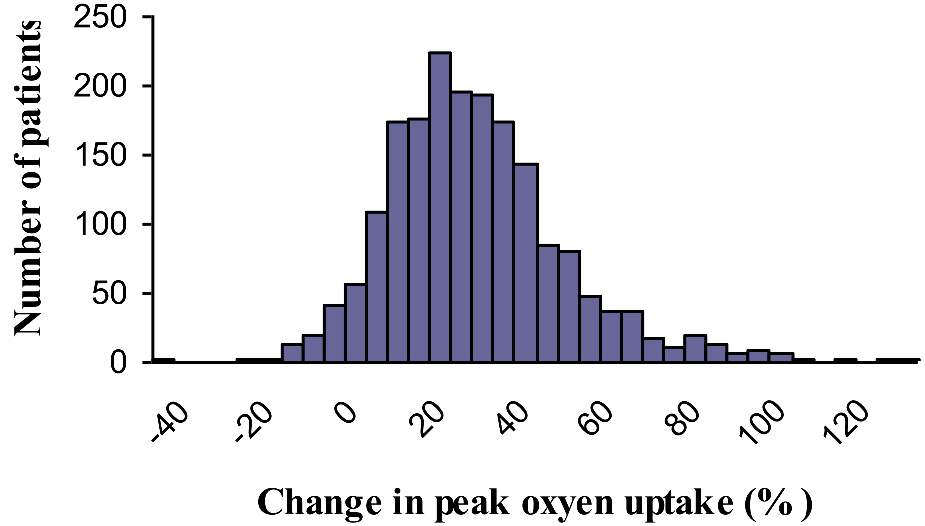
# Diminished Physiologic Fitness Reserve




N= 131; Cyclo Ergometer Test

Ivey FM, 2006




Vanhees et al, Eur J Cardiovasc Prevention Rehab, 2004; 11(4):304-12

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# Determinants of Training effect in CAD

**Table 4 Significant partial correlation coefficients and parameter estimates of absolute and relative changes in peak oxygen uptake: data from multiple regression analysis**

| | Absolute | | Relative | |
|---|---|---|---|---|
| | $r$ | β Intercept=259.9 | $r$ | β Intercept=31.0 |
| Training frequency (*n*/week) | 0.21*** | 130.6 | 0.17*** | 6.81 |
| Training intensity (%) | 0.19*** | 4.12 | 0.23*** | 0.33 |
| Baseline exercise duration (min) | 0.10*** | −8.72 | 0.28*** | −1.74 |
| Age (years) | 0.24*** | −8.57 | 0.19*** | −0.44 |
| Gender (male=0; female=1) | 0.15*** | −187.7 | 0.10*** | −7.91 |
| Complaints of dyspnoea† | 0.10*** | −84.2 | 0.10*** | −5.23 |
| Intermittent claudication† | 0.08** | −125.2 | 0.08** | −7.51 |
| Current smoker† | 0.07** | −88.4 | 0.07** | −5.31 |
| Heart transplantation† | 0.05* | −191.3 | 0.04 | −12.1 |
| Body Mass Index (kg/m$^2$) | 0.05* | 4.80 | NS | – |
| Other cardiac surgery† | 0.06** | −149.9 | 0.06* | −8.61 |
| Treatment with diuretics† | NS | – | 0.06* | −5.30 |
| Treatment with digitalis† | NS | – | 0.07** | 4.12 |
| | $R_2$=0.18 | | $R^2$=0.21 | |

*$P$<0.05; **$P$<0.01; ***$P$<0.001; †Presence of the characteristic was encoded as 1, otherwise 0. NS, not significant.

Vanhees et al. Eur J Cardiovasc Prev Rehabil 2004,11:304-312

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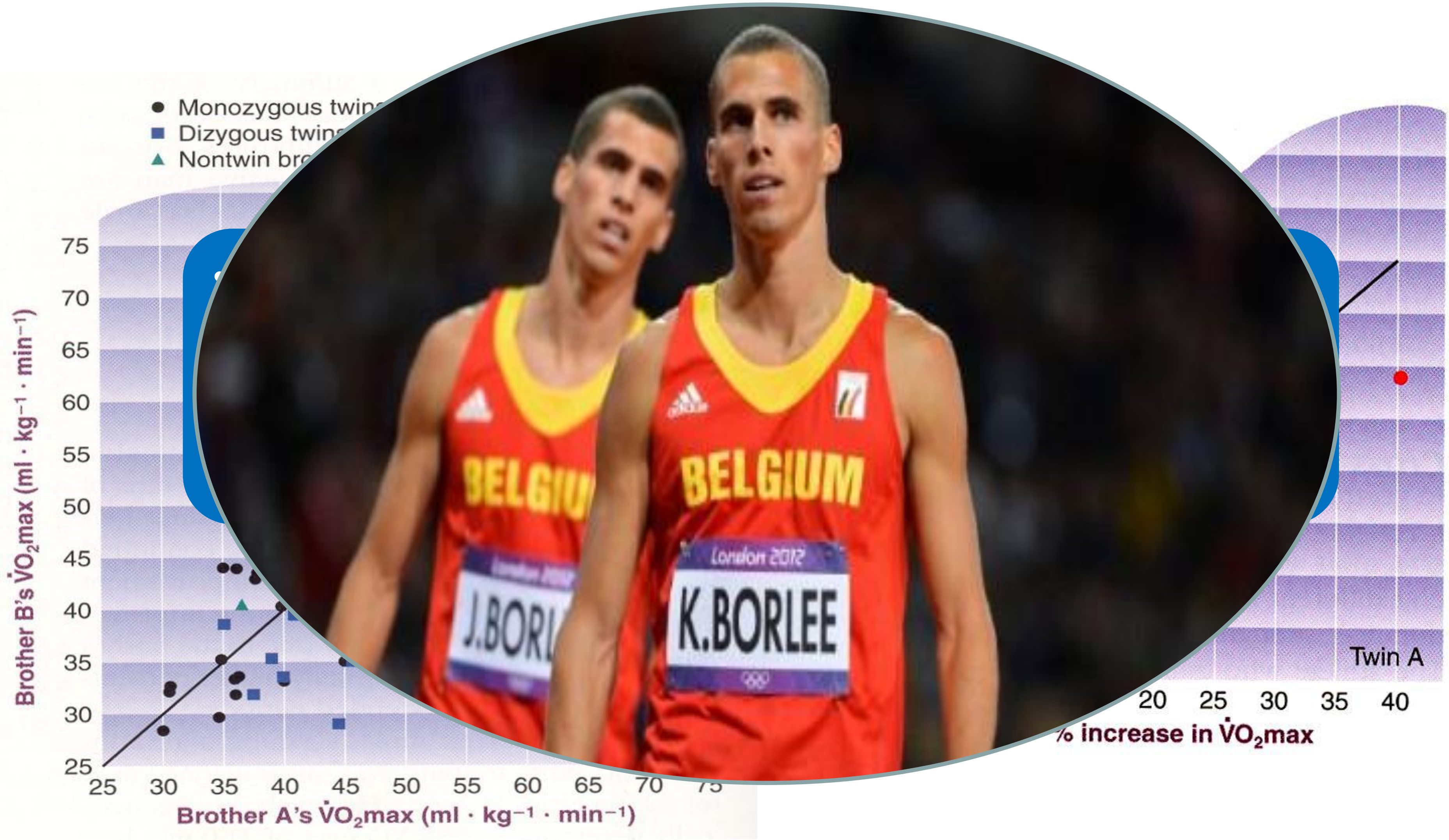
Vanhees et al. Eur J Cardiovasc Prev Rehabil 2004,11:304-312

# Possible additional determinants

- Other variables:
  - Respiratory function
  - Cardiovascular sub-phenotypes: vasodilatation (see later)
    - Autonomic function
    - Endothelial function
    - RAAS
    - …
  - Muscle structure and function (see later)
  - Genetics

# Genetic Determinants: The genetic basis of $VO_2$max and change by training




Bouchard et al, 1990, 1992

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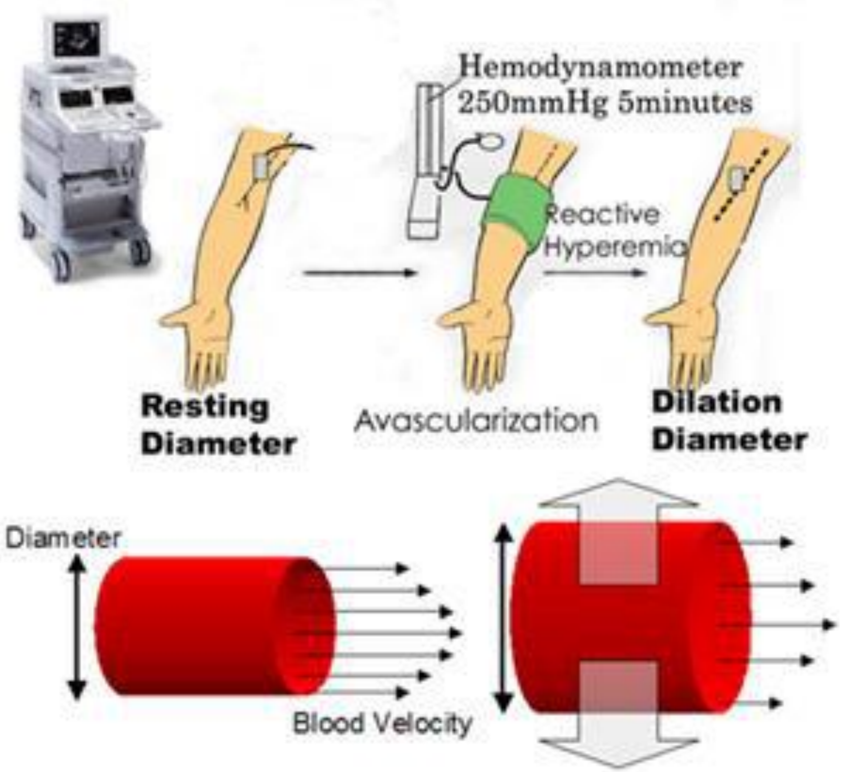
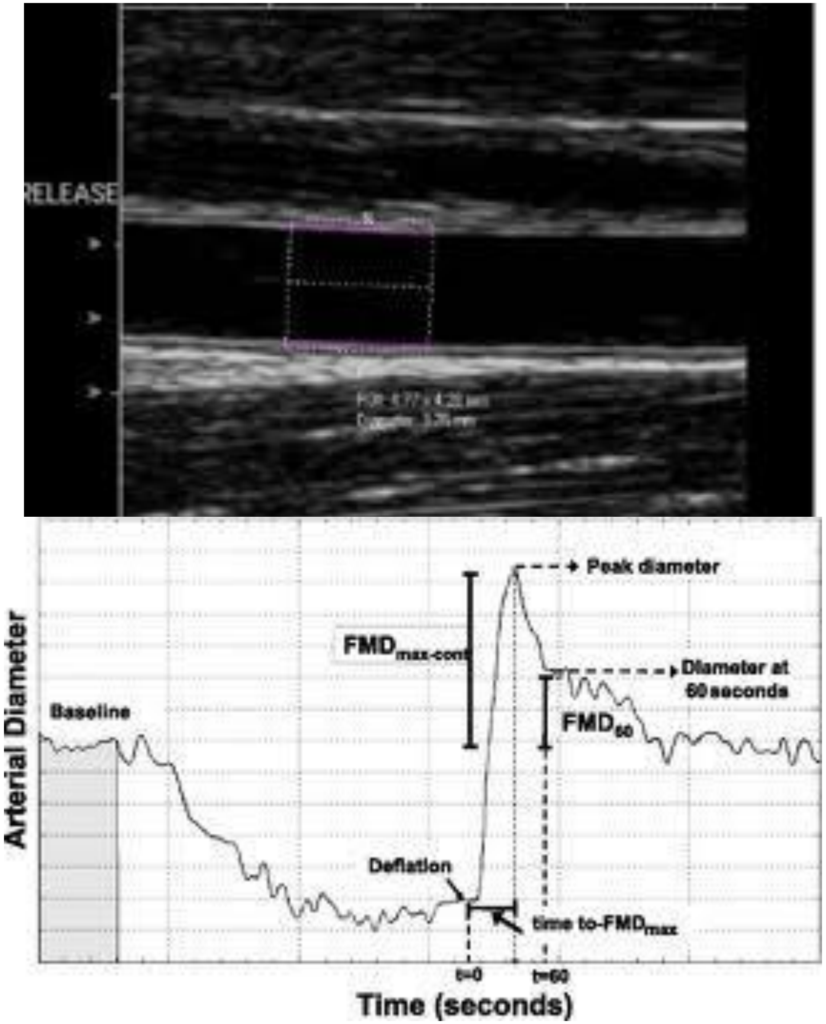
# Endothelial function → **flow-mediated dilation (FMD)**



Original scientific paper

European Journal of Preventive Cardiology

European Journal of Preventive Cardiology
0(00) 1–10

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DOI: 10.1177/2047487312460516
ejpc.sagepub.com
SAGE

# Exercise-based cardiac rehabilitation improves endothelial function assessed by flow-mediated dilation but not by pulse amplitude tonometry*

Véronique A Cornelissen[1,†], Steven Onkelinx[1,†], Kaatje Goetschalckx[2], Tom Thomaes[1], Stefan Janssens[2], Robert Fagard[2], Peter Verhamme[2] and Luc Vanhees[1]

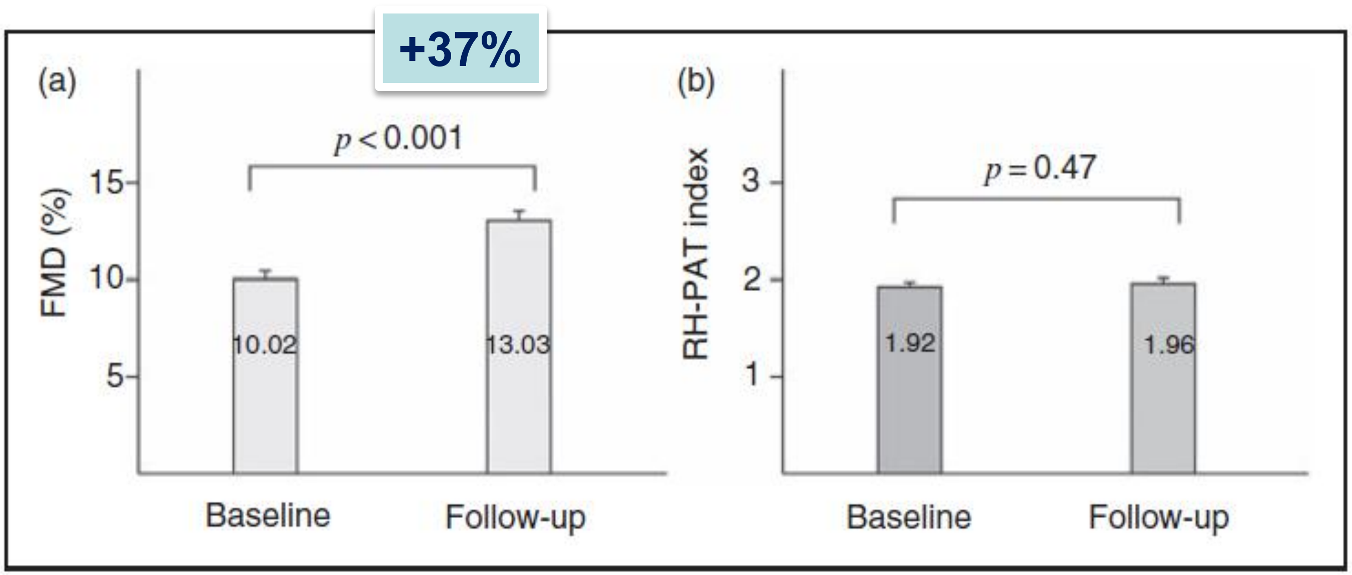
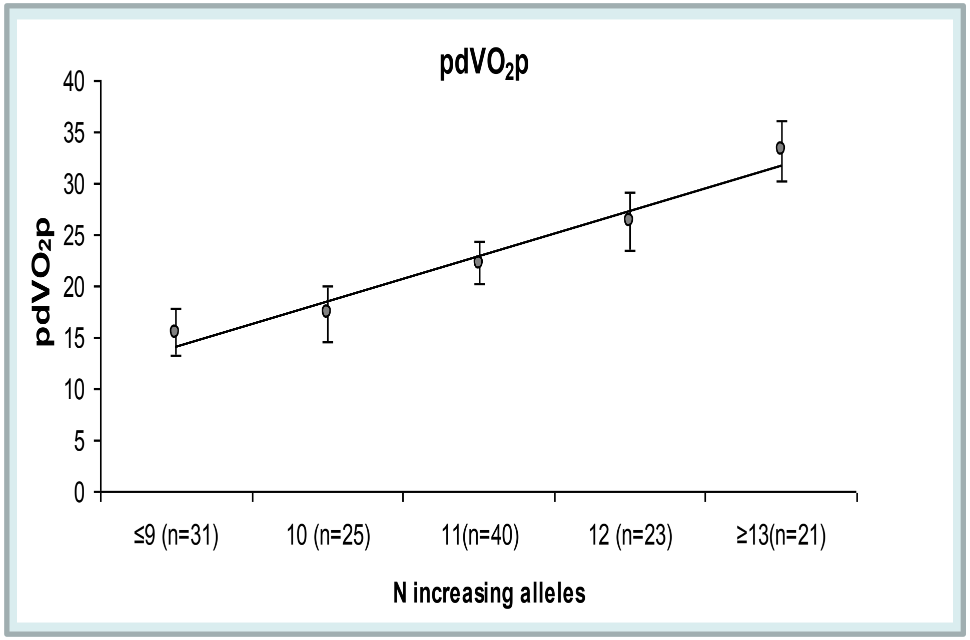



**Figure 1.** FMD at baseline and follow-up (a) and the RH-PAT index at baseline and follow-up (b).

# GPS score of endothelial related SNP's




Significant partial correlation coefficients and parameter estimates of relative changes in $VO_2$peak (%)

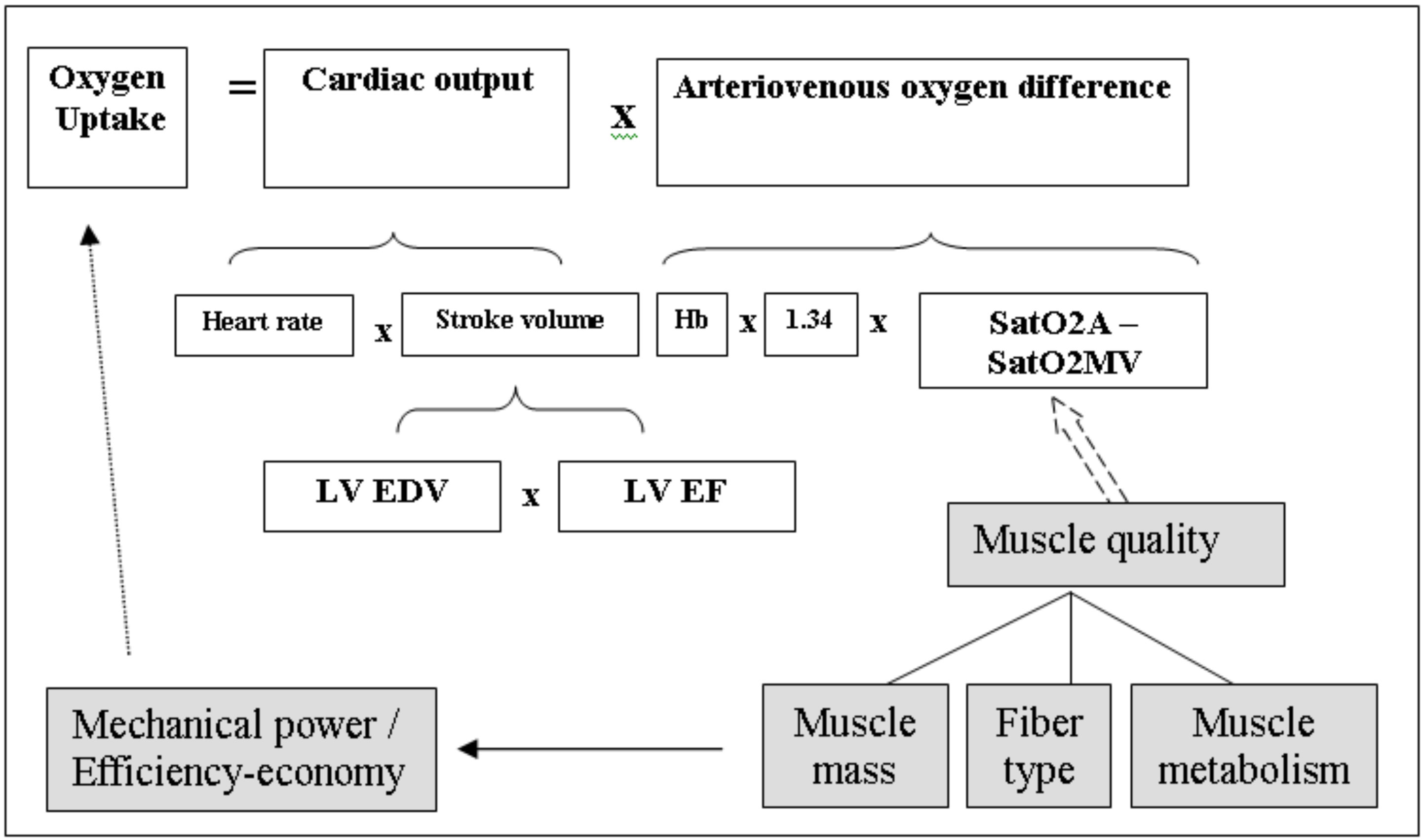
| | r | b-coefficient |
|---|---|---|
| GPS | 0.42*** | 4.32 |
| pdFMD(%) | 0.26** | 0.09 |
| pdHRV(%) | 0.18* | 0.18 |
| Training frequency (n/week) | 0.22* | 6.61 |
| Training intensity ( %) | 0.23** | 0.27 |
| CABG[1] | 0.22** | 5.84 |
| | **$R^2$=0.35** | |

GPS= genetic predisposition scores
pdFMD = relative change in FMD;
pdHRV = relative change in TP of HRV;
*P<0.05; **P<0.01;***P>0.001;
[1] Presence of CABG was encoded as 1, otherwise 0;

Onkelinx et al. 2013

# Muscular function

Fig. 1 Fick equation: Oxygen uptake (hemodynamic parameters), and the inclusion of peripheral muscle function in influencing oxygen uptake



# Skeletal muscle strength

- Muscle strength:
  - Handgrip force
  - Isometric knee extension
  - Isokinetic knee flexion /
  - extension at different speeds
  - (60° - 120° - 180° - 240°/sec)
- Muscle mass
  - M.Quadriceps diameter (rectus femoralis)

# Muscular strength and diameter as determinants of aerobic power and aerobic power response in CAD patients

Acta Cardiol 2012; 67(4): 399-406

Tom THOMAES[1], MSc; Martine THOMIS[2], PhD; Steven ONKELINX[1], MSc; Kaatje Goetschalckx[3], MD; Robert Fagard[3], MD, PhD; Véronique Cornelissen[1], PhD; Luc Vanhees[1], PhD

[1]Research Group for Cardiovascular and Respiratory Rehabilitation, Department of Rehabilitation Sciences, KULeuven, Leuven, Belgium; [2]Exercise and Health Research Group, Department of Biomedical Kinesiology, KULeuven, Leuven, Belgium; [3]Hypertension and Cardiovascular Rehabilitation Unit, Department of Cardiovascular Diseases, KULeuven, Leuven, Belgium

**Objective** Low exercise capacity and skeletal muscle strength are important predictors of all-cause mortality in healthy as well as diseased individuals. Compared to sedentary subjects, CAD patients have a decreased oxygen uptake (peak$VO_2$) and show accompanying increased muscle fatigability. Despite the known importance of oxygen extraction by peripheral muscles on improving peak$VO_2$ and of the relationship between muscle strength and aerobic capacity, only few studies in CAD patients include measurements of muscle strength before and after cardiac rehabilitation. This study therefore aimed to evaluate how much of the variance in baseline peak$VO_2$ and its response to exercise training can be explained by muscular parameters.

**Methods** 260 CAD patients performed maximal incremental cycle ergometer testing and maximal knee muscle strength measurements. Rectus femoris diameter was measured using ultrasound. Zero order correlations were calculated and determinants of baseline and response in peak$VO_2$ were analyzed by multiple regression analysis.

**Results** Peak$VO_2$ and muscle strength and diameter increased significantly after three months of cardiac rehabilitation ($P < 0.0001$). Zero order correlations showed significant correlations between muscular parameters and baseline peak$VO_2$ ($P < 0.0001$). 63% of the total variance in baseline peak$VO_2$ could be explained by seven parameters with knee extensor muscular endurance as the strongest predictor ($P < 0.0001$). 32% of the variation in relative increase in peak$VO_2$ could be explained by 5 determinants of which the increase in muscular endurance was the strongest determinant ($P < 0.0001$).

**Conclusions** Knee extensor muscular endurance and its response after training are the strongest muscular predictors in explaining peak$VO_2$ and its response in CAD patients.

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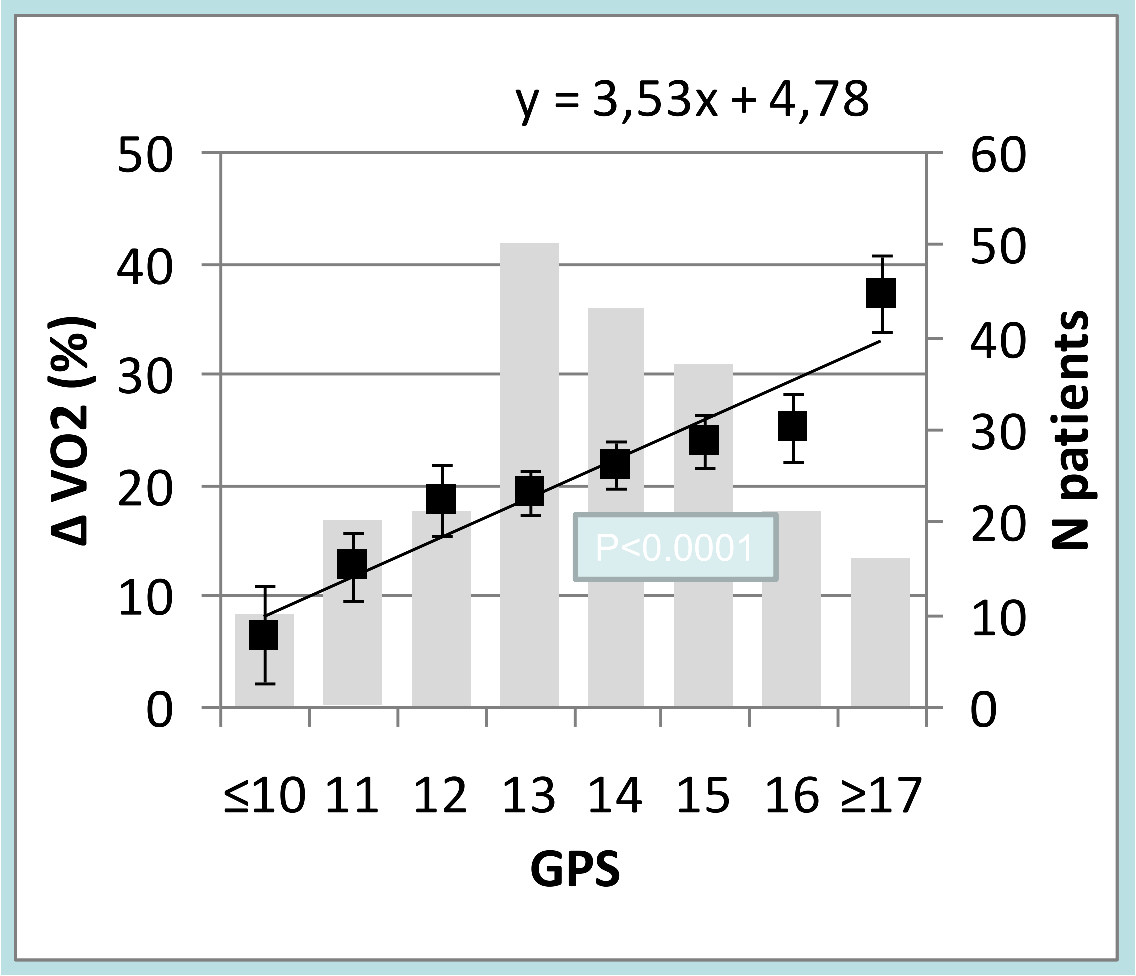
**Table 4** Significant partial correlation coefficients and parameter estimates of baseline peak$VO_2$ and peak$VO_2$ response: data from the multiple regression analysis

| Parameter | Baseline peak$VO_2$ | | Δ Peak$VO_2$ | |
|---|---|---|---|---|
| | r | b-intercept | r | b-intercept |
| Age | −0.17 | −5.87 | - | - |
| Gender | - | - | −0.19* | −7.63 |
| Height | 0.20** | 11.09 | - | - |
| Past smoking | −0.25*** | −144.55 | - | - |
| Fat free mass | 0.22** | 11.09 | - | - |
| CABG | −0.19** | −121.12 | 0.22** | 6.22 |
| Claudicatio intermittens | 0.15* | −190.99 | - | - |
| Muscular endurance (extension) | 0.45*** | 0.28 | / | / |
| Training intensity | / | / | 0.22** | 0.26 |
| Training frequency | / | / | 0.26** | 8.63 |
| Δ Muscular endurance (extension) | / | / | 0.44*** | 0.28 |
| Total variance | $R^2$=0.63 (N=204) | | $R^2$=0.32 (N=150) | |

*$p$< 0.05, **$p$< 0.01, ***$p$< 0.001, CABG: Coronary artery bypass grafting.

Thomaes et al. Acta Cardiol 2012; 67(4): 399-406

# GPS muscular SNP's




Thomaes et al, 2013; Med Sci & Exercise

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# Determinants of Training effect in CAD

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Vanhees et al. Eur J Cardiovasc Prev Rehabil 2004,11:304-312

*Policy statement*

European Journal of Preventive Cardiology
20(3) 442–467

DOI: 10.1177/2047487312460484
ejpc.sagepub.com

# Aerobic exercise intensity assessment and prescription in cardiac rehabilitation: a joint position statement of the European Association for Cardiovascular Prevention and Rehabilitation, the American Association of Cardiovascular and Pulmonary Rehabilitation and the Canadian Association of Cardiac Rehabilitation

Alessandro Mezzani[1]*, Larry F Hamm[2]*, Andrew M Jones[3], Patrick E McBride[4], Trine Moholdt[5], James A Stone[6], Axel Urhausen[7] and Mark A Williams[8]

KA

**Table 5. Evidence-based prescribable aerobic exercise intensity in cardiac patient groups**

| | Exercise intensity domains | | | |
|---|---|---|---|---|
| | Light to moderate | Moderate to high | High to severe | Severe to extreme |
| Stable angina pectoris | √[a] | √[a] | √[a] | |
| Chronic CAD (no residual ischaemia) | √ | √ | √ | √ |
| PCI | √ | √ | √ | |
| Pacemaker | √ | √ | | |
| ICD | √ | √ | | |
| Chronic AF | √[b] | √[b] | | |
| CABG | √ | √ | √ | |
| Valve repair/replacement | √ | √ | | |
| CHF | √ | √ | √ | |
| LVAD | √ | | | |
| Heart transplantation | √[c] | √[c] | √[c] | |

The grey areas identify intensity domains for which no scientific evidence is available in a specific population; CAD: coronary artery disease; PCI: percutaneous coronary intervention; ICD: implantable cardioverter defibrillator; AF: atrial fibrillation; CABG: coronary artery by-pass grafting; CHF: chronic heart failure; LVAD: left ventricular assist device; [a]Heart rate and/or work rate must in any case be lower than those corresponding to the ischaemic threshold; [b]Heart rate may not be usable due to highly variable chronotropic response; [c]Heart rate may not be usable due to denervation-related blunted chronotropic response.

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# Aerobic Interval Training (AIT) versus Moderate Continuous Training (MCT) in CAD

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# Fitt+-principle to describe exercise training characteristcs

Frequency (n sessions/week)

Intensity (%$VO_2$ peak or % peak HR or %HRR)

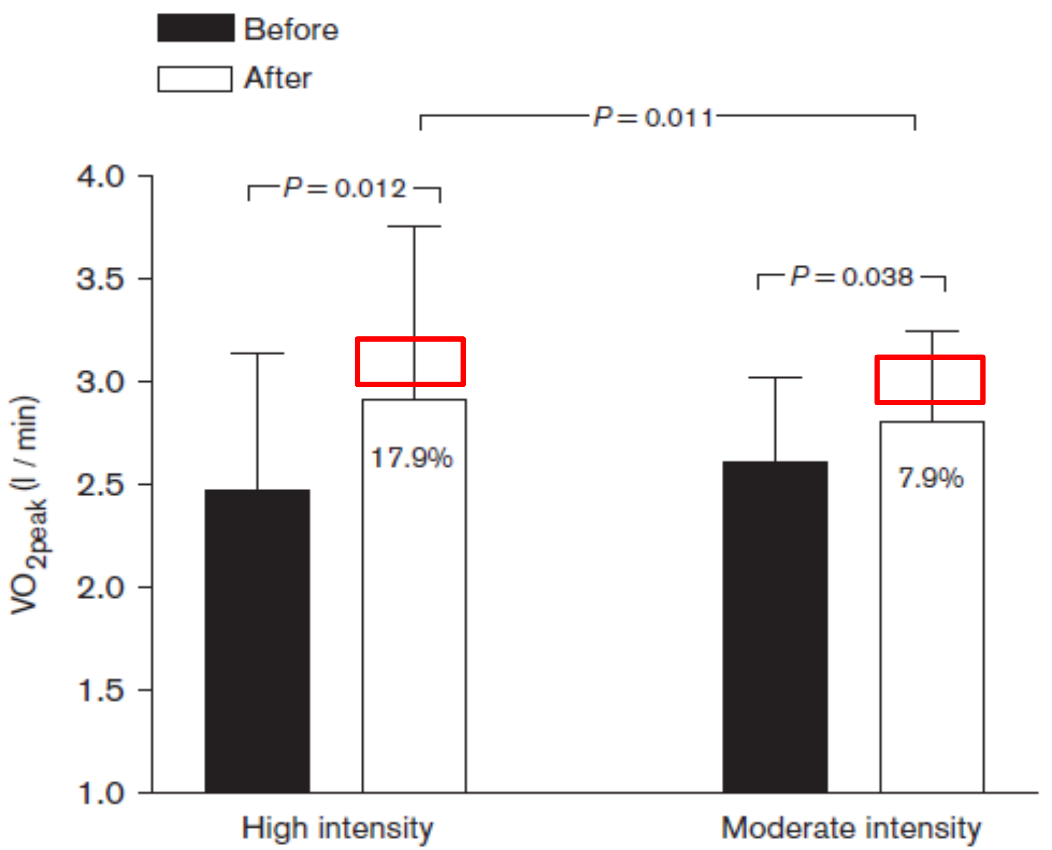
Time (duration of exercise/session/programme)

Type (endurance -running, cycling, rowing, walking, swimming,....- resistance training – flexibility – balance - …)

\+ Mode of training:
- *isometric - isotonic
- *dynamic - static
- *continuous – interval
- *large or small muscular groups

# Mode of exercise training: aerobic interval training versus moderate continuous training in CAD

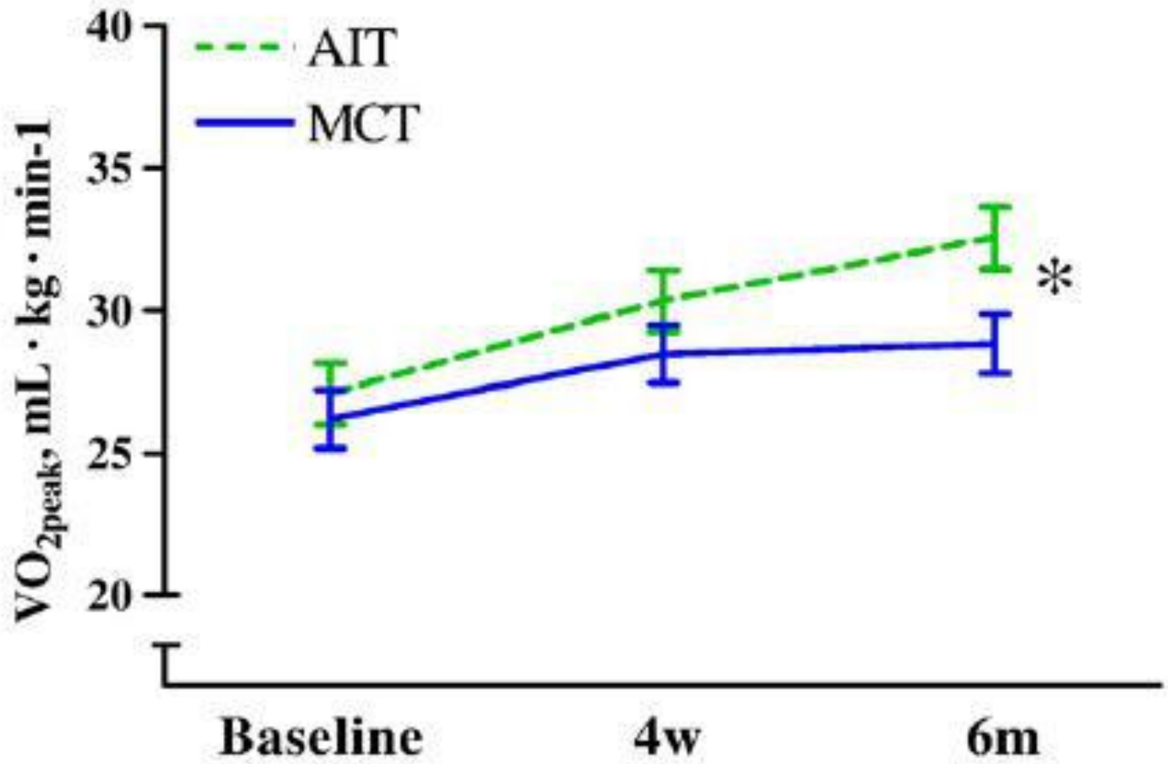
Rognmo (2004): Eur J Cardiovasc Prev Rehab 11:216–222




Peak oxygen uptake ($VO_{2peak}$) before and after aerobic exercise training. Significant differences within groups after training. Increment significantly larger in high intensity group.

# Aerobic Interval Training (AIT) versus Moderate Continuous Training (MCT) in CAD

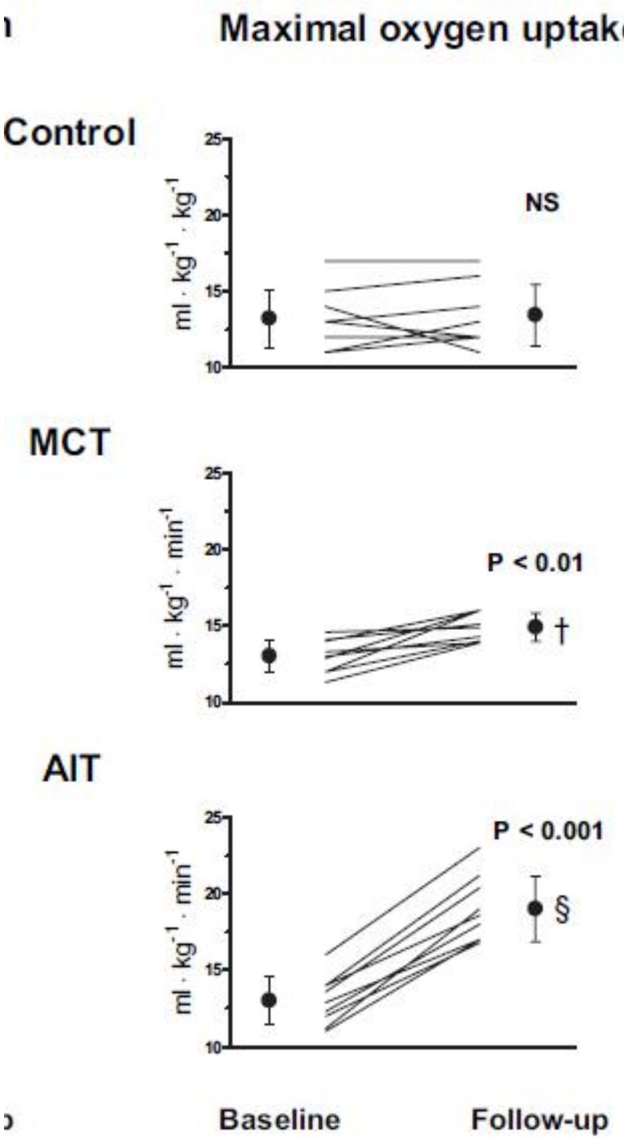
Moholdt, Am Heart J 2009;158:1031-7




$VO_{2peak}$ in AIT and MCT at baseline, 4w, and 6m. The bars represent ± SEM. *$P < .05$, group comparison.

# Aerobic interval training is superior to moderate continuous training in CHF

Wisloff et al, *Circulation. 2007*



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# AIT versus MCT

Sports Med (2014) 44:687–700
DOI 10.1007/s40279-014-0158-x

SYSTEMATIC REVIEW

## Aerobic Interval Training vs. Moderate Continuous Training in Coronary Artery Disease Patients: A Systematic Review and Meta-Analysis

Nele Pattyn · Ellen Coeckelberghs · Roselien Buys · Véronique A. Cornelissen · Luc Vanhees

# Results: primary outcome

## $PeakVO_2$ (ml/kg/min)

| Study or Subgroup | AIT Mean | AIT SD | AIT Total | MCT Mean | MCT SD | MCT Total | Weight | Mean Difference IV, Random, 95% CI |
|---|---|---|---|---|---|---|---|---|
| Currie 2013 | 4.7 | 1.99 | 11 | 3.6 | 2.46 | 10 | 11.9% | 1.10 [-0.83, 3.03] |
| Dimopoulos 2006 | 0.92 | 2.13 | 6 | 0.26 | 2.13 | 5 | 10.3% | 0.66 [-1.87, 3.19] |
| Iellamo 2012 | 4.24 | 2 | 8 | 4.09 | 1.9 | 8 | 12.0% | 0.15 [-1.76, 2.06] |
| Moholdt 2009 | 3.3 | 2.44 | 28 | 2.3 | 2.26 | 31 | 13.8% | 1.00 [-0.20, 2.20] |
| Rocco 2012 | 4.4 | 1.98 | 17 | 4.2 | 2.34 | 20 | 13.4% | 0.20 [-1.19, 1.59] |
| Rognmo 2004 | 6 | 5.72 | 8 | 2.7 | 2.3 | 9 | 6.5% | 3.30 [-0.94, 7.54] |
| Smart 2012 | 3.5 | 3.17 | 6 | 0.21 | 1.24 | 8 | 9.9% | 3.29 [0.61, 5.97] |
| Warburton 2005 | 5.25 | 4.14 | 7 | 4.25 | 2.79 | 7 | 7.5% | 1.00 [-2.70, 4.70] |
| Wisloff 2007 | 6 | 0.96 | 9 | 1.9 | 0.46 | [illegible] | [illegible] | 4.10 [3.40, 4.80] |
| **Total (95% CI)** | | | **10[illegible]** | | | **106** | **100.0%** | **1.60 [0.18, 3.02]** |

Heterogeneity: Tau² = 3.41; Chi² = 47.23, df = 8 (P < 0.00001); I² = 83%
Test for overall effect: Z = 2.22 (P = 0.03)

Mean Difference
IV, Random, 95% CI

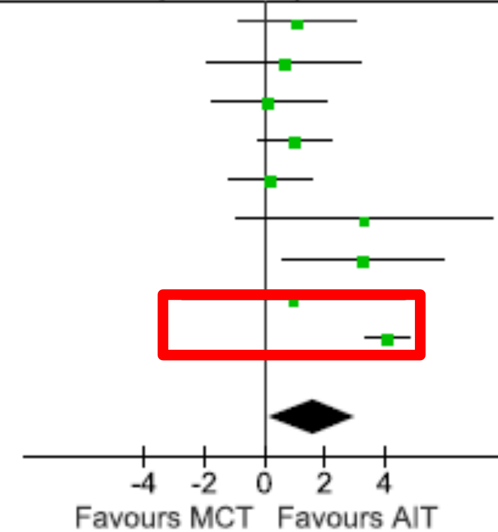


**Fig. 2** Forest plot of the mean effect sizes and corresponding 95 % confidence intervals for peak $VO_2$. *PeakVO₂* peak oxygen uptake, *AIT* aerobic interval training, *MCT* moderate continuous training, *IV* intervention, *CI* confidence interval, *SD* standard deviation

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# Results: secondary outcomes

## Body weight

| Study or Subgroup | AIT Mean | AIT SD | AIT Total | MCT Mean | MCT SD | MCT Total | Weight | Mean Difference IV, Random, 95% CI |
|---|---|---|---|---|---|---|---|---|
| Currie 2013 | -0.6 | 2.2 | 11 | -1.2 | 1.8 | 10 | 21.5% | 0.60 [-1.11, 2.31] |
| Moholdt 2009 | 0.2 | 3.27 | 28 | -0.8 | 2.06 | 31 | 31.6% | 1.00 [-0.41, 2.41] |
| Rocco 2012 | 0.3 | 2.88 | 17 | -0.1 | 6.54 | 20 | 6.2% | 0.40 [-2.78, 3.58] |
| Rognmo 2004 | -0.1 | 1.63 | 8 | -0.8 | 1.33 | 9 | 31.0% | 0.70 [-0.73, 2.13] |
| Warburton 2005 | -3 | 1.4 | 7 | -4 | 3.14 | 7 | 9.7% | 1.00 [-1.55, 3.55] |
| **Total (95% CI)** | | | **71** | | | **77** | **100.0%** | $\boxed{\textbf{0.78 [-0.01, 1.58]}}$ |

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 0.23$, df = 4 (P = 0.99); $I^2 = 0\%$

Test for overall effect: Z = 1.94 $\boxed{(P = 0.05)}$

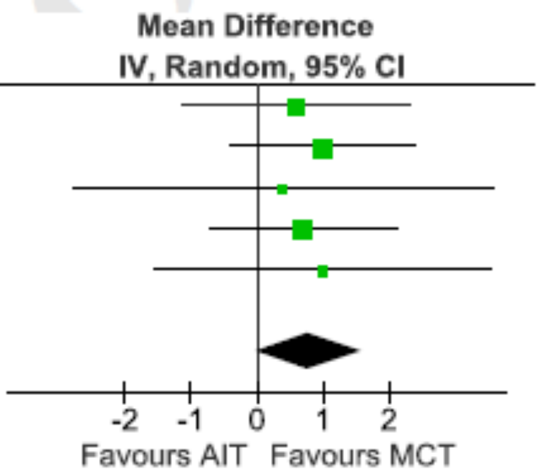


Fig. 5 Forest plot of the mean effect sizes and corresponding 95 % confidence intervals for body weight. *AIT* aerobic interval training, *MCT* moderate continuous training, *IV* intervention, *CI* confidence interval, *SD* standard deviation

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# Results: primary outcome

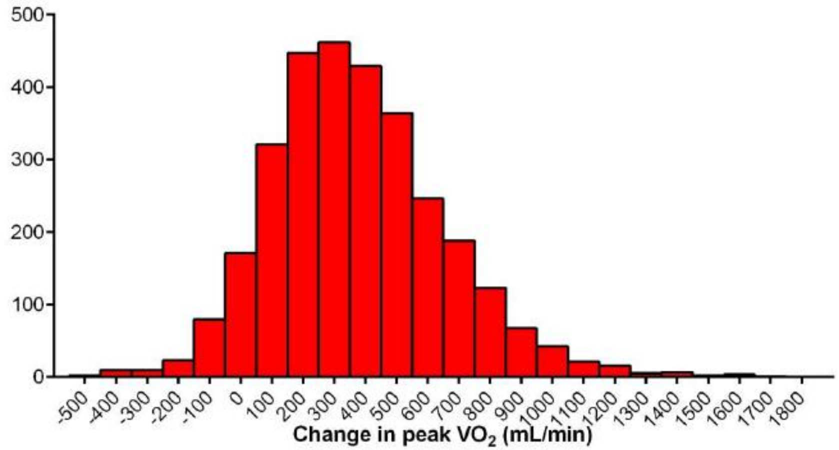
- **AIT group**

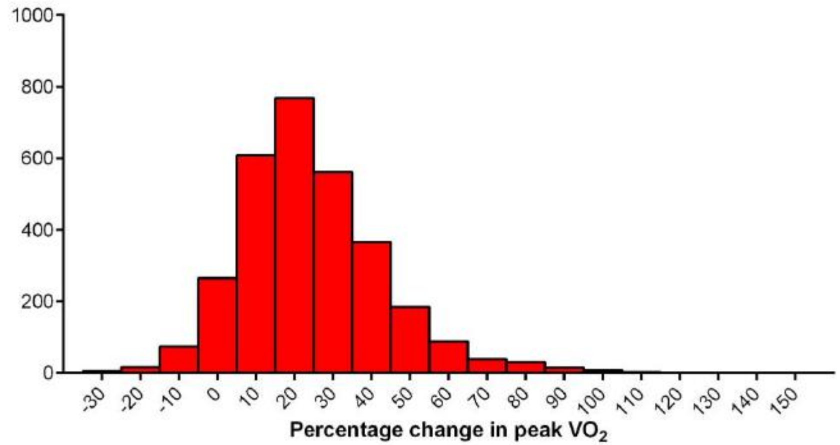
20,4 ml/kg/min → 25,0 ml/kg/min $\boxed{+ 20,2\%}$

- **MCT group**

20,8 ml/kg/min → 23,1 ml/kg/min $\boxed{+ 13,2\%}$

# Change in exercise capacity in 4140 CV patients after 3 months of CR




Average increase + 26%

Vanhees et al, unpublished data, 2014

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# AIT versus MCT

IJCA-16333; No of Pages 5

International Journal of Cardiology xxx (2013) xxx–xxx

Contents lists available at SciVerse ScienceDirect

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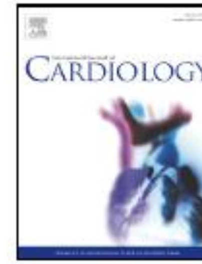


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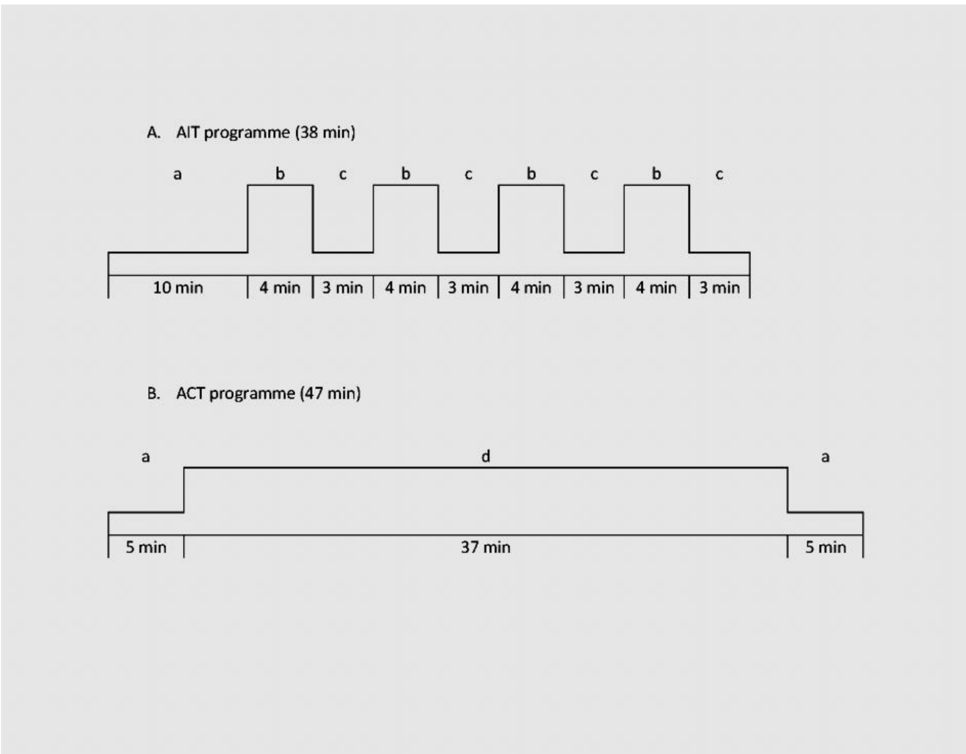
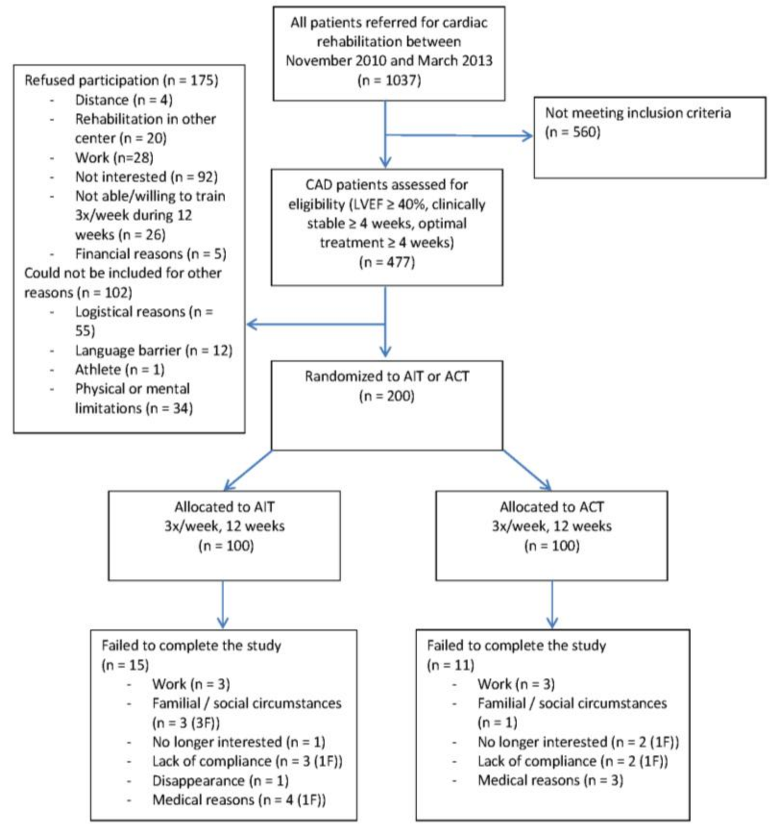
## Rationale and design of a randomized trial on the effectiveness of aerobic interval training in patients with coronary artery disease: The SAINTEX-CAD study

Viviane M. Conraads [a,b,*,1], Emeline M. Van Craenenbroeck [a,b], Nele Pattyn [c,d], Véronique A. Cornelissen [c,d], Paul J. Beckers [a,b], Ellen Coeckelberghs [c,d], Catherine De Maeyer [a,b], Johan Denollet [a,e], Geert Frederix [a], Kaatje Goetschalckx [c,d], Vicky Y. Hoymans [a,b], Nadine Possemiers [a], Dirk Schepers [c,d], Bharati Shivalkar [a,b], Luc Vanhees [c,d,1]

[a] *Department of Cardiology, Antwerp University Hospital, Edegem, Belgium*
[b] *University of Antwerp, Antwerp, Belgium*
[c] *University Hospitals of Leuven, Leuven, Belgium*
[d] *Department of Rehabilitation Sciences, Research Centre for Cardiovascular and Respiratory Rehabilitation, Katholieke Universiteit Leuven, Heverlee, Belgium*
[e] *CoRPS–Centre of Research on Psychology in Somatic diseases, Tilburg University, Tilburg, The Netherlands*

# Saintex-CAD study



# Saintex-CAD study

International Journal of Cardiology 179 (2015) 203–210

Contents lists available at ScienceDirect

International Journal of Cardiology

journal homepage: www.elsevier.com/locate/ijcard

## Aerobic interval training and continuous training equally improve aerobic exercise capacity in patients with coronary artery disease: The SAINTEX-CAD study☆

Viviane M. Conraads [a,b,1], Nele Pattyn [c,2], Catherine De Maeyer [a,b,2], Paul J. Beckers [a,b], Ellen Coeckelberghs [c], Véronique A. Cornelissen [c], Johan Denollet [a,d], Geert Frederix [a,e], Kaatje Goetschalckx [c,f], Vicky Y. Hoymans [a,b,e], Nadine Possemiers [a], Dirk Schepers [c], Bharati Shivalkar [a,b], Jens-Uwe Voigt [f], Emeline M. Van Craenenbroeck [a,b,e], Luc Vanhees [c,f,*]

[a] Department of Cardiology, Antwerp University Hospital, Edegem, Belgium
[b] University of Antwerp, Antwerp, Belgium
[c] Department of Rehabilitation Sciences, KU Leuven, Leuven, Belgium
[d] CoRPS-Centre of Research on Psychology in Somatic diseases, Tilburg University, Tilburg, The Netherlands
[e] Laboratory of Cellular and Molecular Cardiology, Antwerp University Hospital, Edegem, Belgium
[f] Department of Cardiovascular Diseases, University Hospitals of Leuven, Leuven, Belgium

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# Saintex-CAD study

**Table 1**
Baseline characteristics of the participants.

| | Total group | AIT | ACT | Significance |
|---|---|---|---|---|
| Sample size | 200 | 100 | 100 | |
| *Characteristics* | | | | |
| Gender (M/F) | 180/20 | 91/9 | 89/11 | NS |
| Age (years) | 58.4 ± 9.1 | 57.0 ± 8.8 | 59.9 ± 9.2 | P = 0.023 |
| Height (cm) | 173 ± 8.0 | 174 ± 7.6 | 173 ± 8.4 | NS |
| Weight (kg) | 84.9 ± 14.0 | 84.7 ± 14.4 | 85.0 ± 13.7 | NS |
| BMI (kg/m$^2$) | 28.3 ± 4.3 | 28.0 ± 4.4 | 28.5 ± 4.3 | NS |
| Waist (cm) | 99.7 ± 11.7 | 100 ± 12.0 | 99.4 ± 11.6 | NS |
| Peak $VO_2$ (ml/kg/min) | 22.7 ± 5.69 | 23.3 ± 5.78 | 22.2 ± 5.56 | NS |
| FMD (%)[a] | 5.62 ± 2.84 | 5.53 ± 3.15 | 5.71 ± 2.50 | NS |
| *Reason for referral* | | | | |
| AMI | 115 | 67 | 48 | P = 0.007 |
| PCI | 25 | 7 | 18 | P = 0.019 |
| CABG | 60 | 26 | 34 | NS |
| Duration of CAD | | | | NS |
| ≤3 months | 156 | 83 | 73 | |
| >3 months | 44 | 17 | 27 | |
| LVEF (%) | 56.9 ± 8.1 | 57.1 ± 8.5 | 56.8 ± 7.7 | NS |
| *Cardiovascular risk factors* | | | | |
| Hypertension | 104 | 58 | 46 | NS |
| Diabetes | 38 | 20 | 18 | NS |
| History of COPD | 4 | 3 | 2 | NS |
| Familial predisposition | 50 | 21 | 29 | NS |
| Smoking | | | | NS |
| Never | 53 | 27 | 26 | |
| Ex | 122 | 59 | 63 | |
| Current | 25 | 14 | 11 | |
| Alcohol consumption (drinks/week) | 4.2 ± 5.7 | 4.7 ± 6.5 | 3.7 ± 4.7 | NS |

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# Saintex-CAD study

| | | | | |
|---|---|---|---|---|
| *Medication* | | | | |
| Beta-blockers | 167 | 84 | 83 | NS |
| Anti-hypertensive medication | 149 | 77 | 72 | NS |
| Nitrates | 9 | 5 | 4 | NS |
| Diuretics | 25 | 10 | 15 | NS |
| Anti-arrhythmics | 4 | 3 | 1 | NS |
| ASA | 188 | 93 | 95 | NS |
| Anti-thrombotics | 147 | 76 | 71 | NS |
| Vitamin K antagonists | 15 | 9 | 6 | NS |
| Digitalis | 2 | 1 | 1 | NS |
| Statins | 196 | 97 | 99 | NS |
| Antidiabetic medication | 37 | 18 | 19 | NS |

Data are expressed as means ± standard deviation (SD) for continuous variables or as percentages for dichotomous variables.
AIT = aerobic interval training; ACT = aerobic continuous training; M = male; F = female; NS = not significant; BMI = body mass index; peak $VO_2$ = peak oxygen uptake; FMD = flow-mediated dilation; AMI = acute myocardial infarction; PCI = -percutaneous coronary intervention; CABG = coronary artery bypass grafting; CAD = coronary artery disease; LVEF = left ventricular ejection fraction; COPD = chronic obstructive pulmonary disease; ASA = acetylsalicylic acids.

[a] FMD data were available in 188 patients (AIT and ACT, n = 94).

# Saintex-CAD study

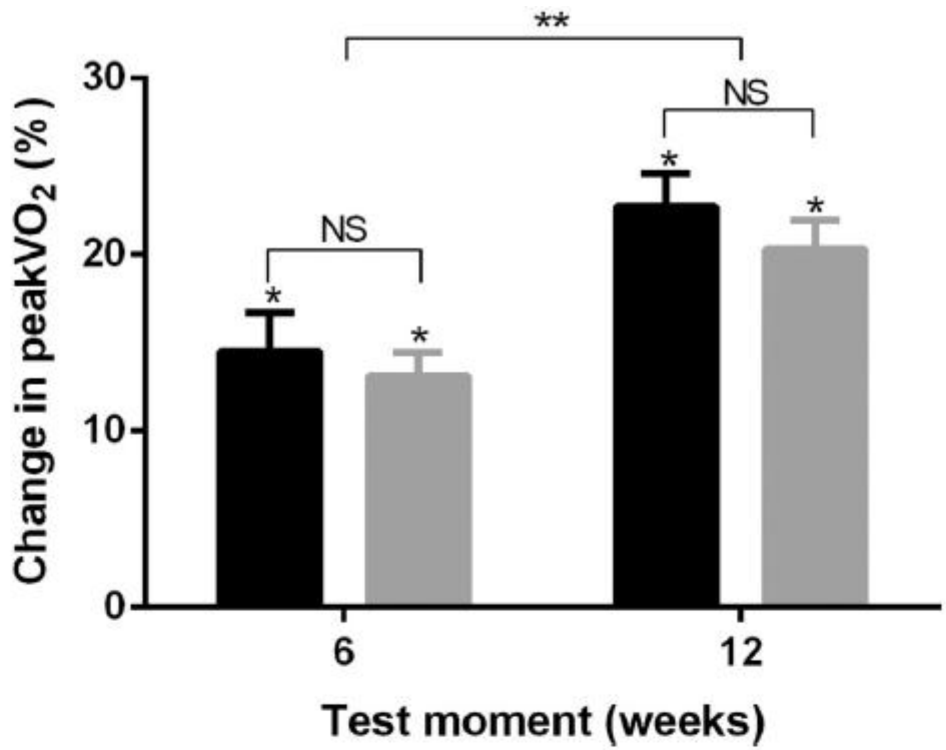


**Fig. 3.** Percent changes in peak $VO_2$ in AIT and ACT after 6 and 12 weeks. Data are means ± SEM; * = significantly different from baseline ($p < 0.001$); ** = 6 weeks differs significantly from 12 weeks ($p = 0.0231$); NS = not significant; black bars = AIT; grey bars = ACT.

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# Saintex-CAD: Data at peak exercise

**Table 2**

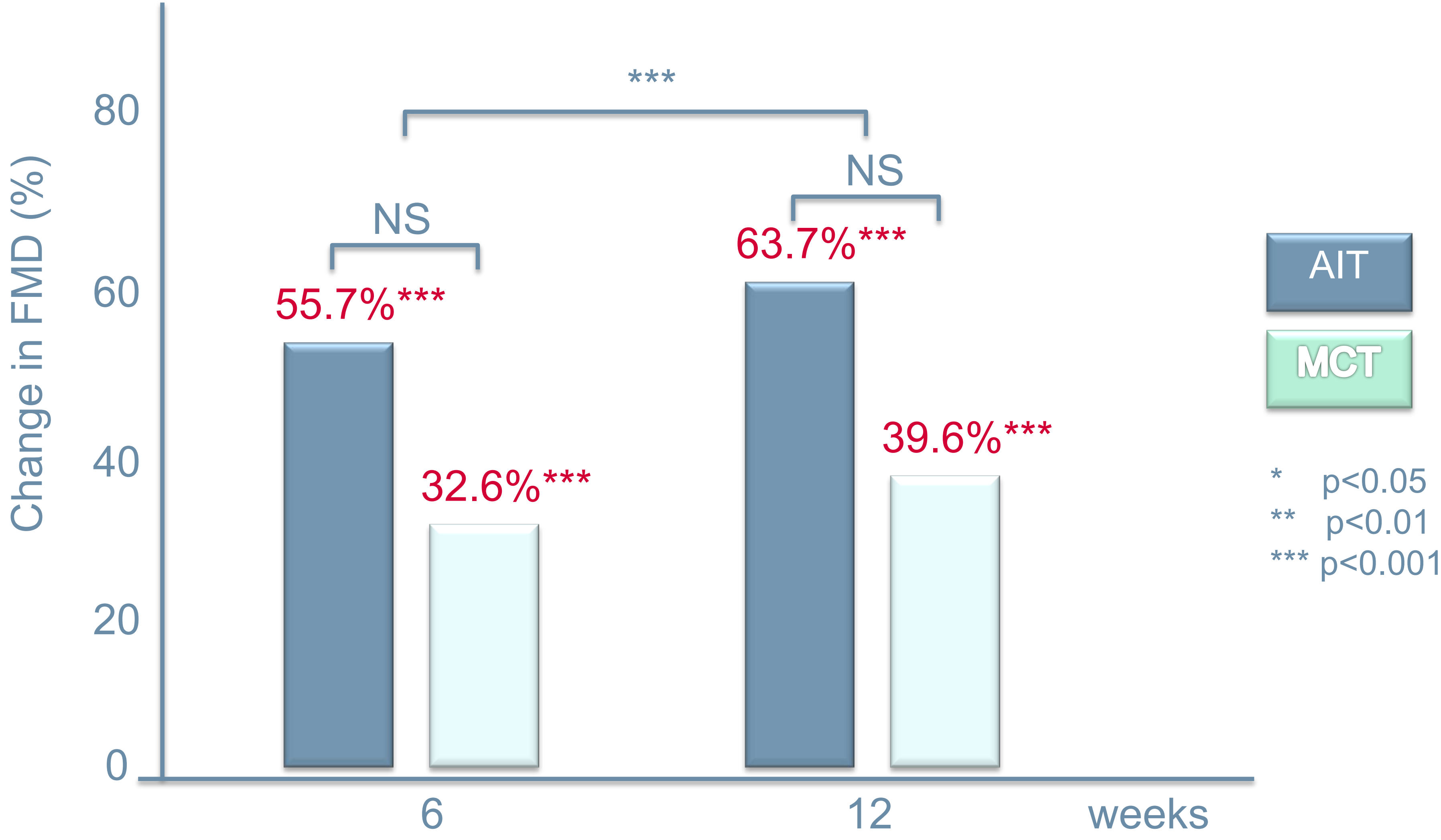
Peak exercise capacity parameters at baseline, after 6 and after 12 weeks of AIT or ACT.

| | AIT (n = 85) | | | ACT (n = 89) | | | F-values | | |
|---|---|---|---|---|---|---|---|---|---|
| Parameter | 0 weeks | 6 weeks | 12 weeks | 0 weeks | 6 weeks | 12 weeks | Time | Group | Interaction |
| $VO_2$ (ml/min) | 1965 ± 503 | 2232 ± 548 | 2395 ± 560 | 1887 ± 473 | 2116 ± 527 | 2238 ± 550 | 31.69***,a,b,c | 3.34§ | $0.31^{NS}$ |
| $VO_2$/kg (ml/kg/min) | 23.5 ± 5.7 | 26.7 ± 6.7 | 28.6 ± 6.9 | 22.4 ± 5.6 | 25.2 ± 6.2 | 26.8 ± 6.7 | 28.18***,a,b,c | 3.87* | $0.16^{NS}$ |
| HR (bpm) | 134 ± 21.0 | 140 ± 19.0 | 145 ± 18.2 | 129 ± 21.1 | 134 ± 22.3 | 138 ± 21.5 | 12.84***,a,b | 10.38** | $0.13^{NS}$ |
| Workload (Watt) | 154 ± 38.8 | 177 ± 44.9 | 192 ± 46.9 | 145 ± 41.0 | 169 ± 47.9 | 180 ± 46.6 | 39.42***,a,b,c | 3.98* | $0.17^{NS}$ |
| RER | 1.26 ± 0.12 | 1.27 ± 0.12 | 1.28 ± 0.11 | 1.26 ± 0.11 | 1.26 ± 0.09 | 1.27 ± 0.09 | $0.84^{NS}$ | $0.28^{NS}$ | $0.20^{NS}$ |
| $O_2$ pulse | 14.8 ± 3.6 | 16.0 ± 3.5 | 16.6 ± 3.5 | 14.7 ± 2.9 | 15.9 ± 3.3 | 16.2 ± 3.2 | 12.32***,a,b | $0.04^{NS}$ | $0.07^{NS}$ |

Data are expressed as means ± standard deviation (SD). All data are corrected for age and pathology.

AIT = aerobic interval training; ACT = aerobic continuous training; n = number of patients; $VO_2$ = oxygen uptake; NS = not significant; HR = heart rate; bpm = beats per minute; RER = respiratory exchange ratio; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$; §$p = 0.068$; a = 6 weeks differed significantly from baseline; b = 12 weeks differed significantly from baseline; c = 12 weeks differed significantly from 6 weeks.

# SAINTEX-CAD TRIAL



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# Saintex-CAD study

**Table 4**
Cardiovascular risk factors and quality of life at baseline and after 12 weeks of AIT or ACT.

| Parameter | AIT (n = 85) 0 weeks | AIT (n = 85) 12 weeks | ACT (n = 89) 0 weeks | ACT (n = 89) 12 weeks | F-values Time | F-values Group | F-values Interaction |
|---|---|---|---|---|---|---|---|
| Weight (kg) | 84.6 ± 14.5 | 85.1 ± 14.2 | 85.1 ± 13.9 | 84.6 ± 13.4 | $0.00^{NS}$ | $0.13^{NS}$ | $0.07^{NS}$ |
| BMI (kg/m$^2$) | 27.9 ± 4.1 | 28.0 ± 3.9 | 28.5 ± 4.3 | 28.2 ± 4.2 | $0.01^{NS}$ | $0.92^{NS}$ | $0.11^{NS}$ |
| Waist (cm) | 99.7 ± 11.7 | 98.8 ± 11.5 | 99.5 ± 11.3 | 97.6 ± 10.9 | $1.66^{NS}$ | $0.34^{NS}$ | $0.15^{NS}$ |
| Resting HR | 57.7 ± 7.9 | 55.4 ± 7.4 | 59.4 ± 10.5 | 55.4 ± 8.1 | $6.48^{**}$ | $0.01^{NS}$ | $0.80^{NS}$ |
| SBP (mm Hg) | 125 ± 14.3 | 125 ± 14.3 | 128 ± 17.2 | 122 ± 13.3 | $2.45^{\$}$ | $0.85^{NS}$ | $2.18^{NS}$ |
| DBP (mm Hg) | 75.8 ± 8.4 | 74.7 ± 8.4 | 76.2 ± 10.6 | 72.5 ± 8.2 | $3.08^{*}$ | $1.08^{NS}$ | $0.83^{NS}$ |
| Fasting glucose (mmol/l) | 5.40 ± 1.04 | 5.59 ± 1.42 | 5.29 ± 0.81 | 5.47 ± 1.32 | $2.20^{NS}$ | $2.49^{NS}$ | $0.00^{NS}$ |
| Cholesterol (mmol/l) | 3.61 ± 0.71 | 3.78 ± 0.74 | 3.60 ± 0.78 | 3.76 ± 0.78 | $4.36^{*}$ | $1.20^{NS}$ | $0.01^{NS}$ |
| HDL-C (mmol/l) | 1.13 ± 0.27 | 1.21 ± 0.26 | 1.11 ± 0.28 | 1.20 ± 0.31 | $9.25^{**}$ | $2.63^{NS}$ | $0.10^{NS}$ |
| Cholesterol/HDL-C ratio | 3.33 ± 0.96 | 3.23 ± 0.85 | 3.41 ± 0.96 | 3.27 ± 0.89 | $1.38^{NS}$ | $0.92^{NS}$ | $0.03^{NS}$ |
| LDL-C (mmol/l) | 1.88 ± 0.51 | 1.97 ± 0.53 | 1.98 ± 0.66 | 2.05 ± 0.66 | $1.57^{NS}$ | $0.55^{NS}$ | $0.01^{NS}$ |
| Triglycerides (mmol/l) | 1.49 ± 0.99 | 1.47 ± 0.90 | 1.28 ± 0.49 | 1.25 ± 0.47 | $0.09^{NS}$ | $4.42^{*}$ | $0.00^{NS}$ |
| hs-CRP (log mg/l)$^{§}$ | 0.21 ± 0.44 | 0.12 ± 0.52 | 0.24 ± 0.57 | 0.07 ± 0.52 | $5.67^{*}$ | $0.20^{NS}$ | $0.51^{NS}$ |
| QoL Physical component | 43.5 ± 8.1 | 47.7 ± 7.5 | 42.4 ± 7.7 | 46.8 ± 6.1 | $14.62^{***}$ | $0.35^{NS}$ | $0.74^{NS}$ |
| QoL Mental component | 36.1 ± 7.8 | 38.6 ± 7.7 | 35.8 ± 7.5 | 38.8 ± 5.7 | $7.98^{***}$ | $0.05^{NS}$ | $0.15^{NS}$ |

Data are expressed as means ± standard deviation (SD). All data are corrected for age and pathology.
AIT = aerobic interval training; ACT = aerobic continuous training; n = number of patients; NS = not significant; BMI = body mass index; HR = heart rate; bpm = beats per minute; SBP = systolic blood pressure; DBP = diastolic blood pressure; HDL-C = high density lipoprotein cholesterol; LDL-C = low density lipoprotein cholesterol; hs-CRP = high sensitivity C-reactive protein; QoL = quality of life (AIT n = 76, ACT n = 83); $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$; $^{\$}p = 0.066$; $^{§}$data for hs-CRP were log transformed.

# Saintex-CAD: Data at peak exercise

**Table 2**
Peak exercise capacity parameters at baseline, after 6 and after 12 weeks of AIT or ACT.

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| Workload (Watt) | 154 ± 38.8 | 177 ± 44.9 | 192 ± 46.9 | 145 ± 41.0 | 169 ± 47.9 | 180 ± 46.6 | 39.42***,a,b,c | 3.98* | $0.17^{NS}$ |
| RER | 1.26 ± 0.12 | 1.27 ± 0.12 | 1.28 ± 0.11 | 1.26 ± 0.11 | 1.26 ± 0.09 | 1.27 ± 0.09 | $0.84^{NS}$ | $0.28^{NS}$ | $0.20^{NS}$ |
| $O_2$ pulse | 14.8 ± 3.6 | 16.0 ± 3.5 | 16.6 ± 3.5 | 14.7 ± 2.9 | 15.9 ± 3.3 | 16.2 ± 3.2 | 12.32***,a,b | $0.04^{NS}$ | $0.07^{NS}$ |

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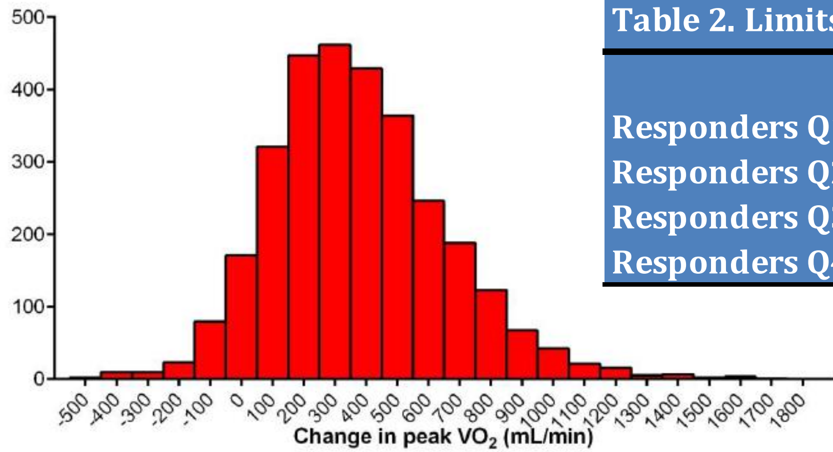
AIT = aerobic interval training; ACT = aerobic continuous training; n = number of patients; $VO_2$ = oxygen uptake; NS = not significant; HR = heart rate; bpm = beats per minute; RER = respiratory exchange ratio; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$; §$p = 0.068$; a = 6 weeks differed significantly from baseline; b = 12 weeks differed significantly from baseline; c = 12 weeks differed significantly from 6 weeks.

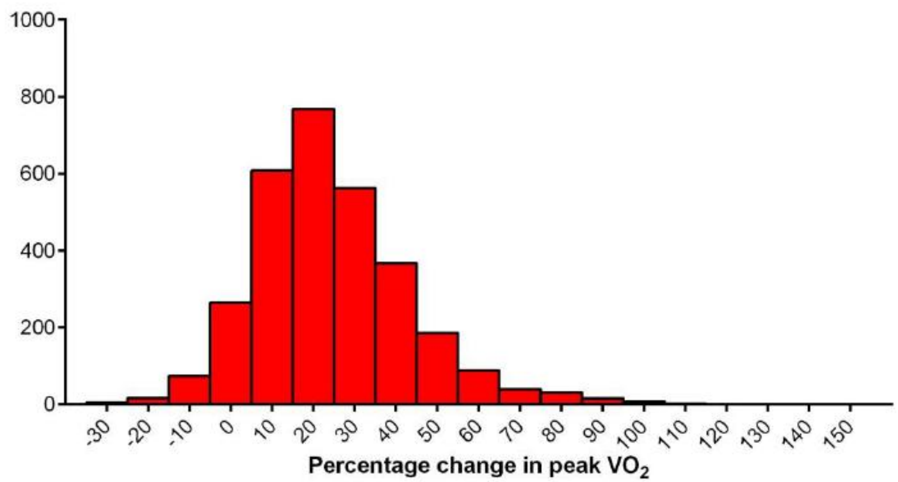
# Trainingseffect bij 3035 CAD patiënten

Vanhees et al, unpublished data, 2014

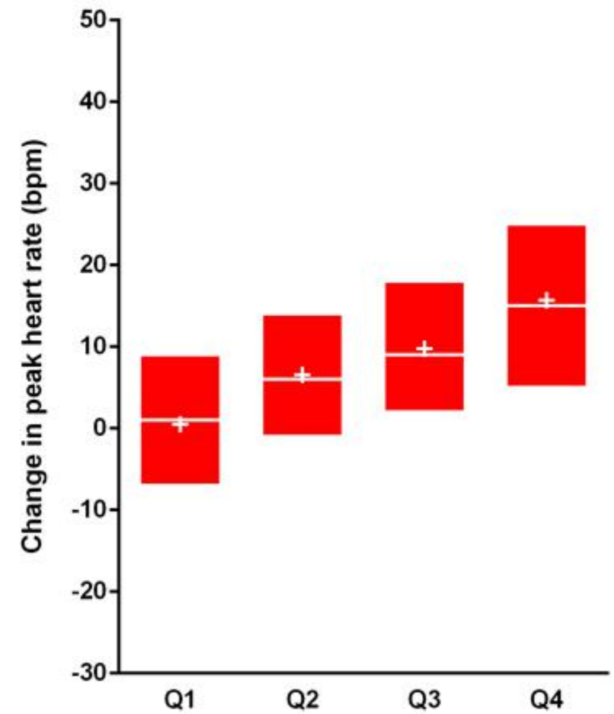
**Table 2. Limits of Responders Quartiles in deltaVO$_2$**

| | deltaVO$_2$ (mL/min) | deltaVO$_2$ (%) |
|---|---|---|
| Responders Q1 | < 184 | < 11,9 |
| Responders Q2 | ≥184 and< 349 | ≥11,9 and< 22,0 |
| Responders Q3 | ≥349 and < 536 | ≥22,0 and < 34,6 |
| Responders Q4 | ≥ 536 | ≥ 34,6 |

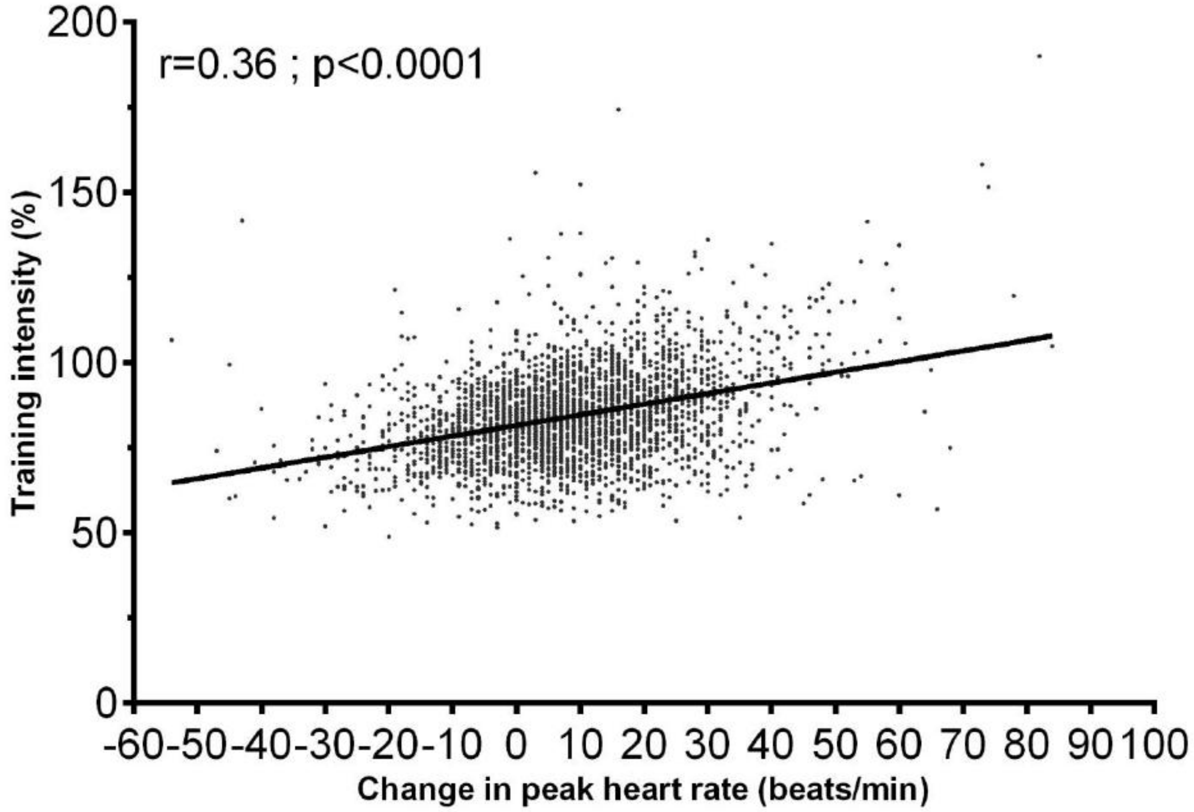



Average increase + 26%



# Importance of training intensity



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# Cardiac Rehabilitation –KU Leuven


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*Original scientific paper*

European Journal of Preventive Cardiology
0(00) 1–11

DOI: 10.1177/2047487316631200
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# The long-term effects of a randomized trial comparing aerobic interval versus continuous training in coronary artery disease patients: 1-year data from the SAINTEX-CAD study

**Nele Pattyn[1,*], Luc Vanhees[1,2,*], Véronique A Cornelissen[1], Ellen Coeckelberghs[1], Catherine De Maeyer[3,4], Kaatje Goetschalckx[2], Nadine Possemiers[3], Kurt Wuyts[3,4], Emeline M Van Craenenbroeck[3,4,5,*] and Paul J Beckers[3,4,*]**

**Conclusion:** The short-term improvements of center-based AIT and ACT on physical fitness, physical activity, peripheral endothelial function, cardiovascular risk factors and QoL are sustained after a 1-year follow-up period. The majority of patients (>90%) met the recommended physical activity levels of 150 minutes/week.

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ExeRcise is Medicine™

Send2Press® Newswire

# Exercise is medicine


## Conclusion

**Yes, we do have different pills and dosages in exercise medicine!**

# Exercise is medicine


Send2Press® Newswire


## Conclusion

**Yes, the beneficial effects are maintained when patients continue to exercise and to increase their physical activity pattern.**

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# Recommendations from the EACPR: Part III

European Journal of Preventive Cardiology

EUROPEAN SOCIETY OF CARDIOLOGY®

Review

European Journal of Preventive Cardiology
19(6) 1333–1356

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DOI: 10.1177/2047487312437063
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## Importance of characteristics and modalities of physical activity and exercise in the management of cardiovascular health in individuals with cardiovascular disease (Part III)

L Vanhees[1], B Rauch[2], M Piepoli[3], F van Buuren[4], T Takken[5], M Börjesson[6], B Bjarnason-Wehrens[7], P Doherty[8], D Dugmore[9] and M Halle[10] (on behalf of the writing group of the EACPR)

KU LEUVEN

Cardiovascular and Respiratory Rehabilitation Research Unit

Thanks for your attention!