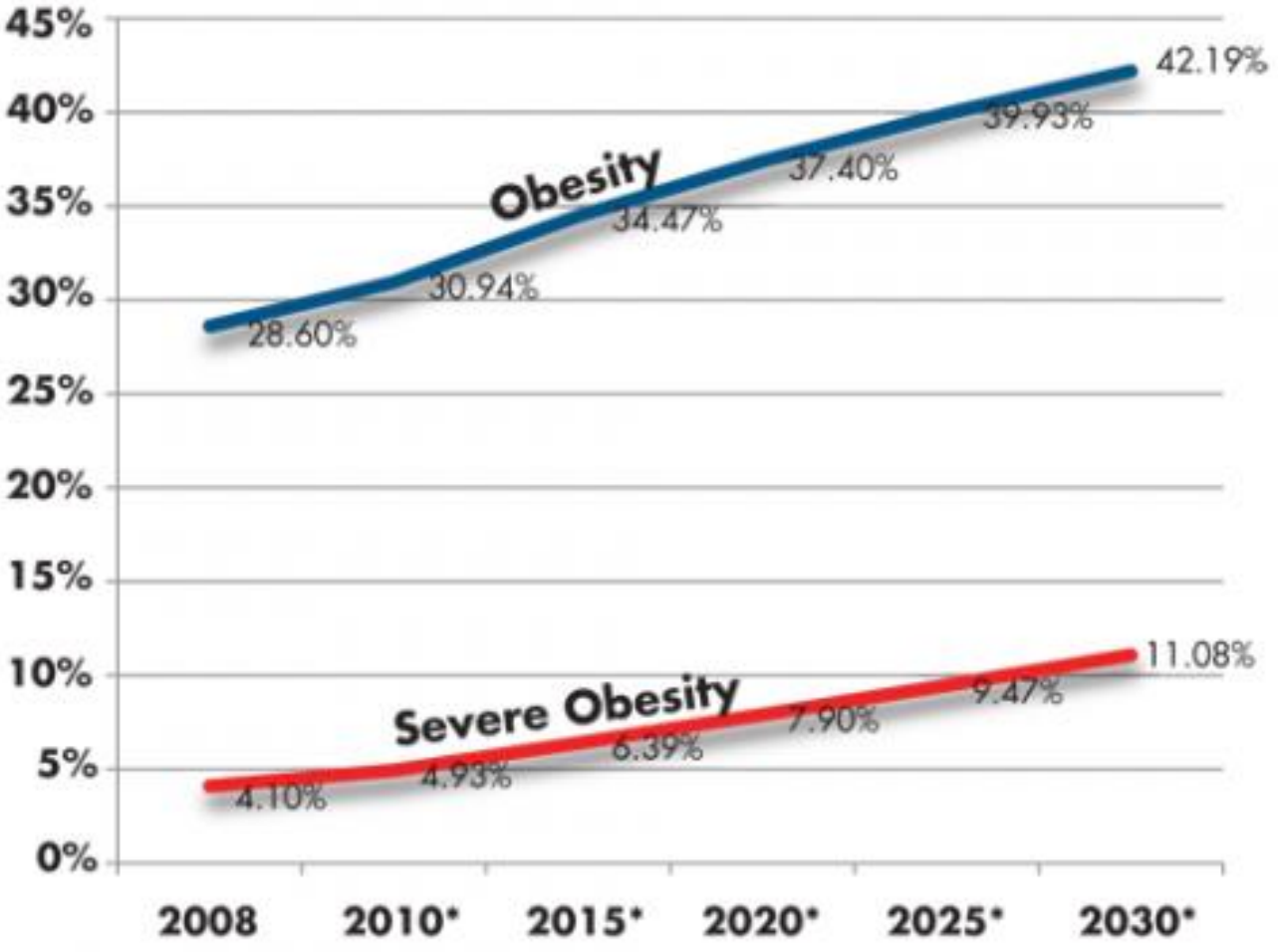
KineCoaches diabetes

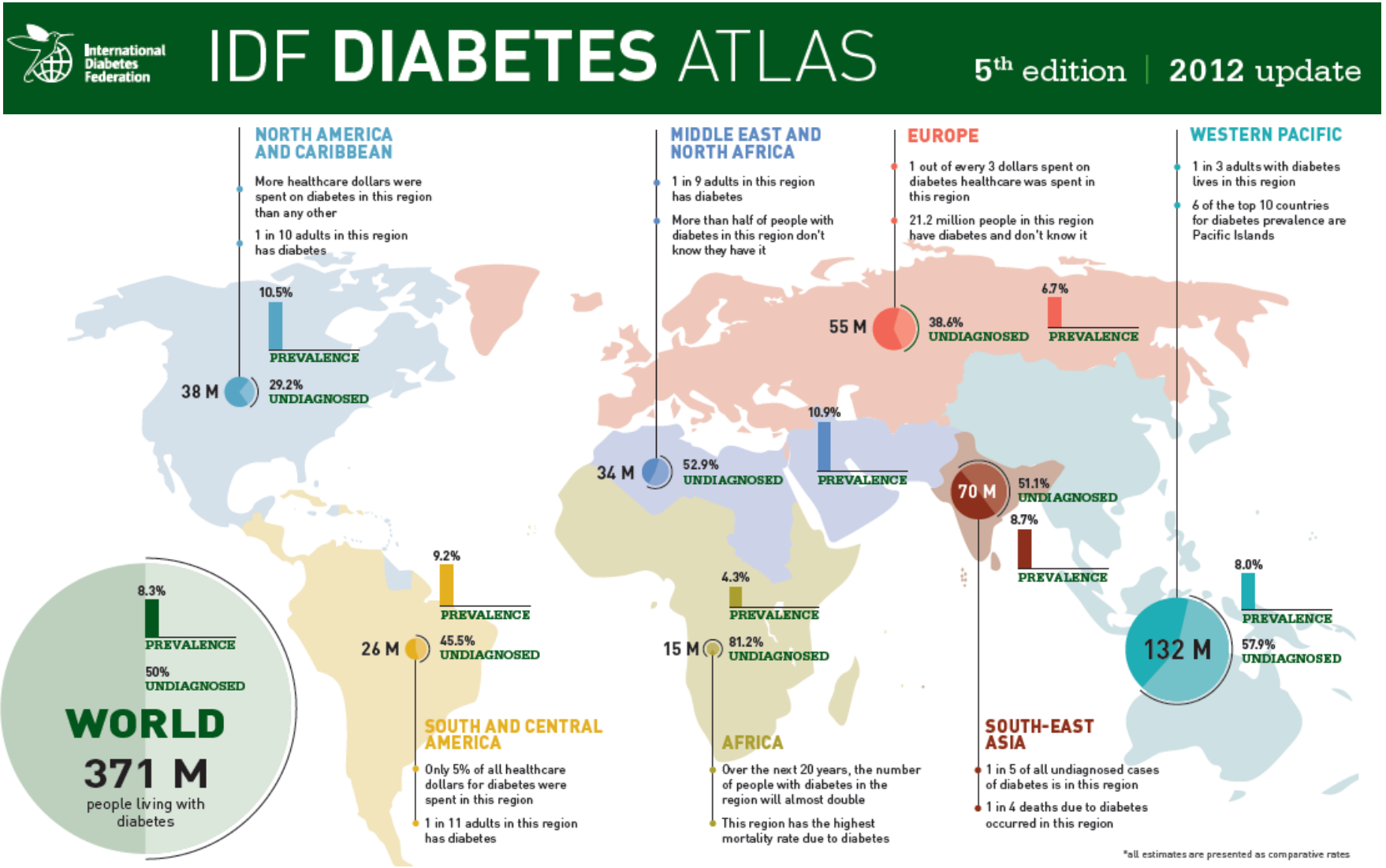
Prof. dr. Dominique Hansen

Obesity epidemic

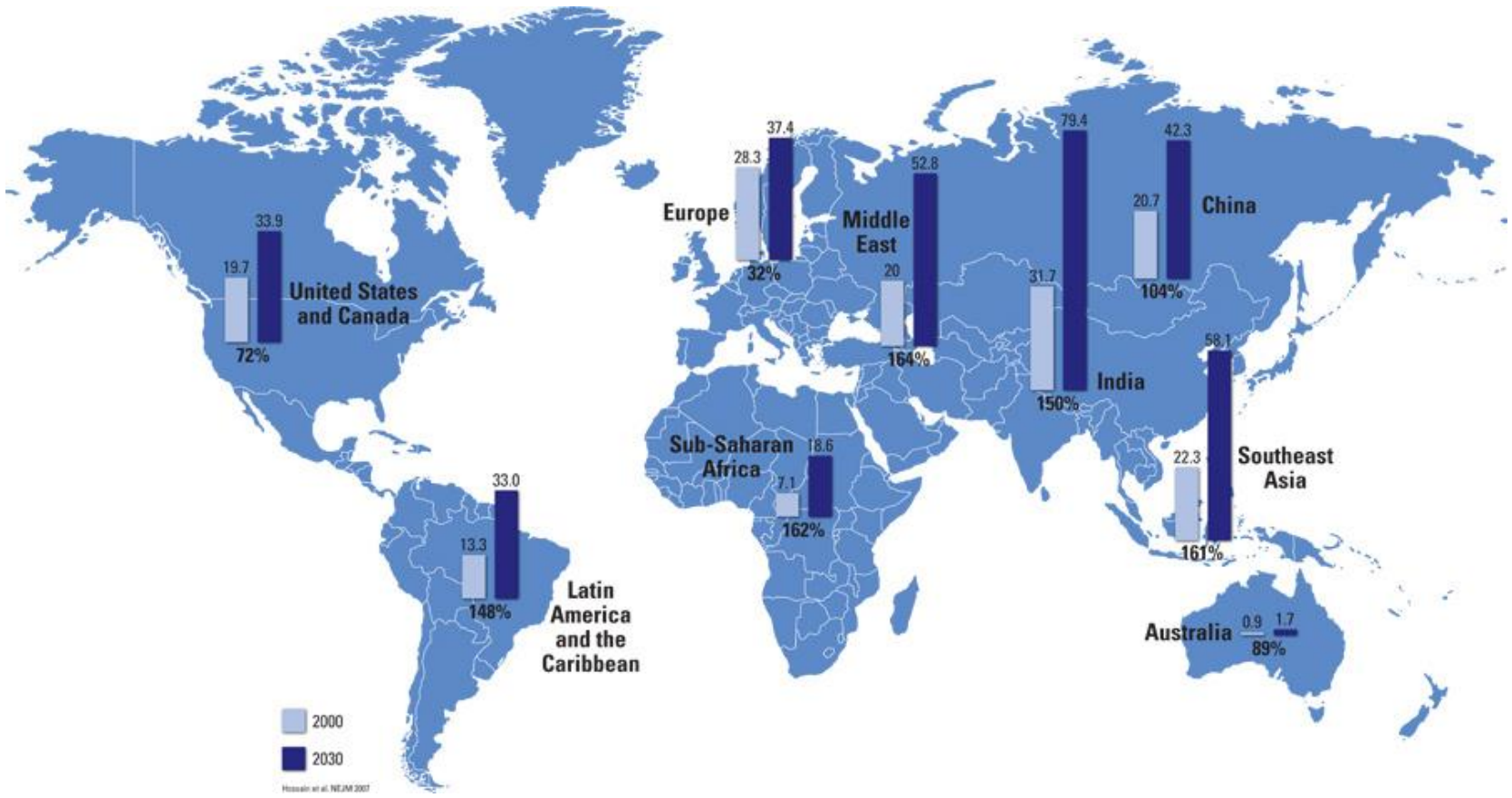
Prevalence of obesity and severe obesity 2008–30 in USA



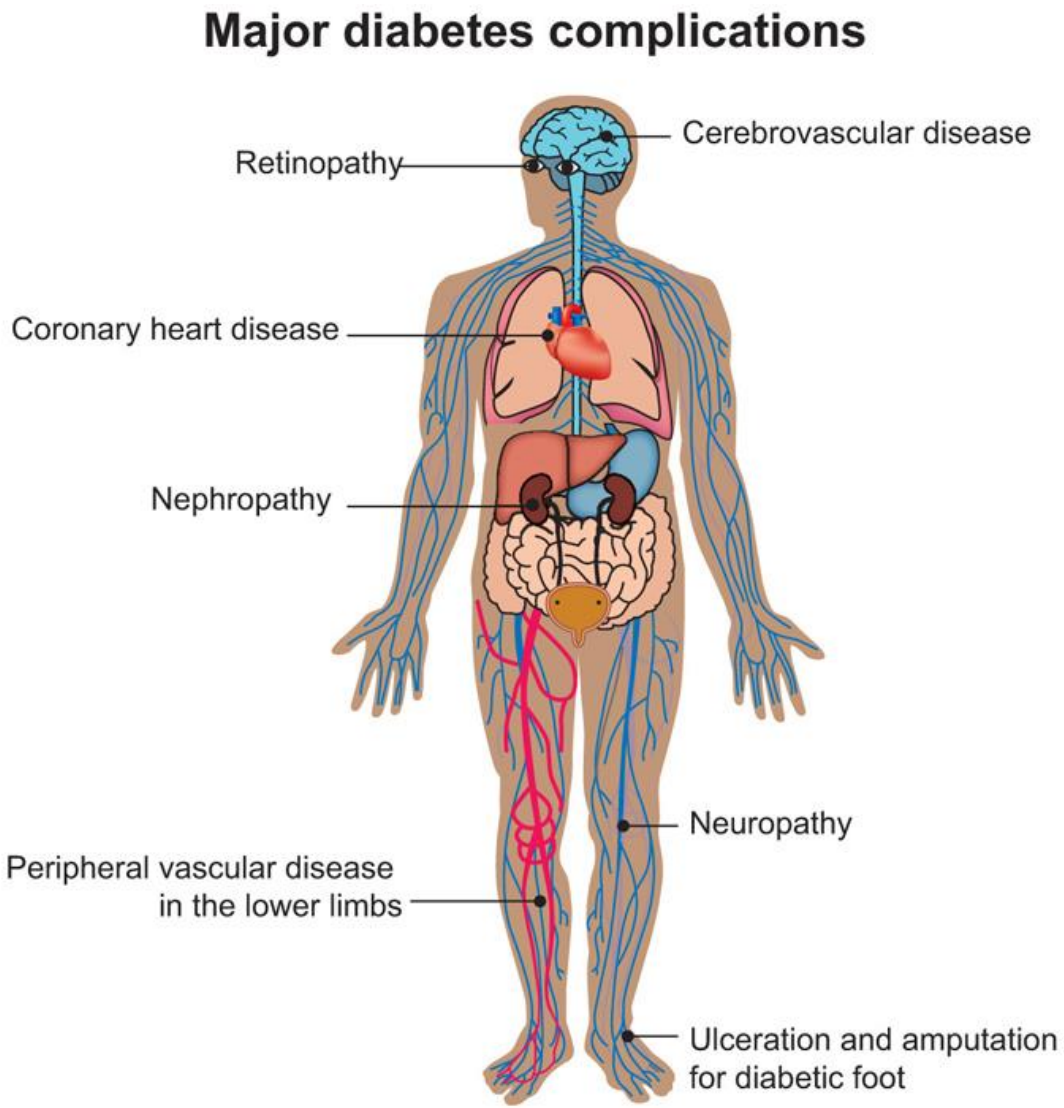
Diabetes epidemic



Diabetes epidemic



Diabetes epidemic



Diabetes epidemic

QD1 How often do you exercise or play sport?

	Regularly	With some regularity	Seldom	Never	Don't know
EU28	8%	33%	17%	42%	0%
Gender					
Man	9%	36%	18%	37%	0%
Woman	7%	30%	16%	47%	0%
Age					
15-24	11%	53%	17%	19%	0%
25-39	8%	38%	21%	33%	0%
40-54	8%	31%	20%	41%	0%
55 +	8%	22%	12%	58%	0%

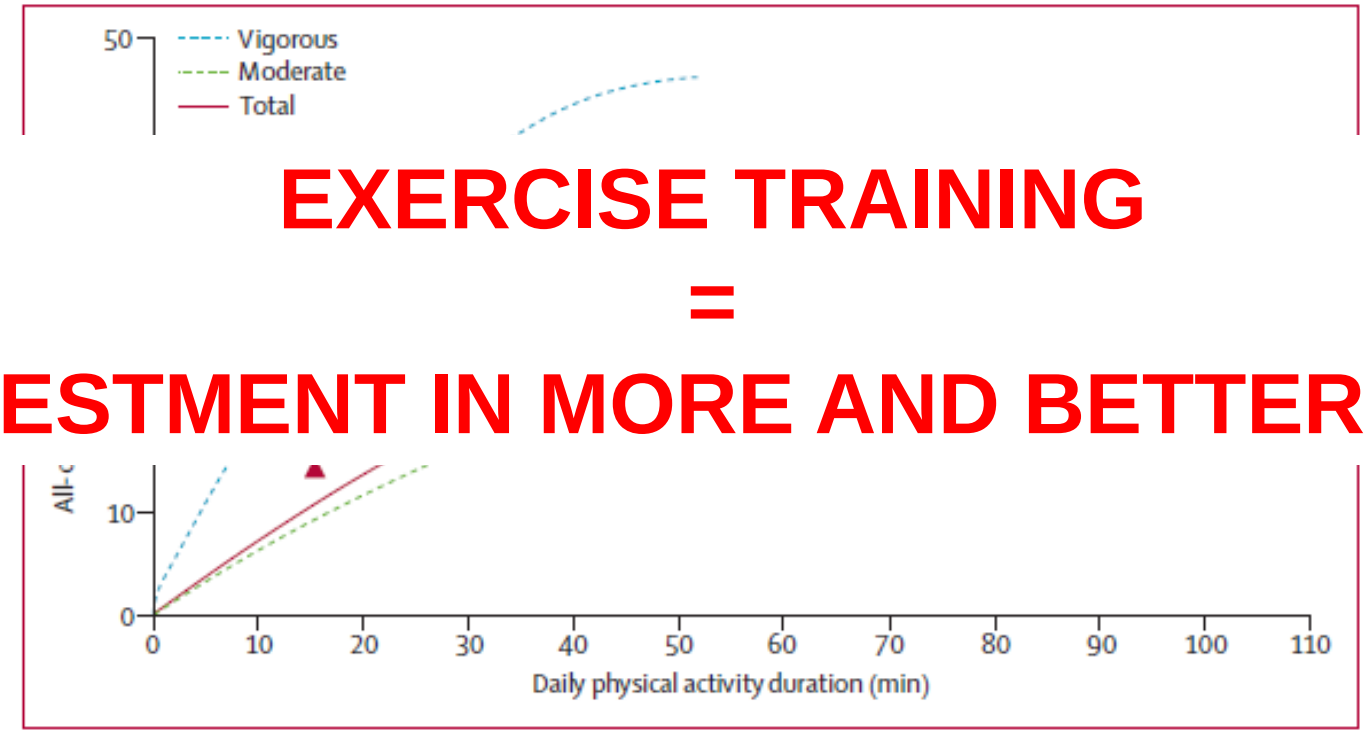
European Opinion Research Group: Eurobarometer Report 2014

Exercise: why?

Minimum amount of physical activity for reduced mortality and extended life expectancy: a prospective cohort study

Chi Pang Wen, Jackson Pui Man Wai*, Min Kuang Tsai, Yi Chen Yang, Ting Yuan David Cheng, Meng-Chih Lee, Hui Ting Chan, Chwen Keng Tsao, Shan Pou Tsai, Xifeng Wu*

416 175 individuals **average follow-up of 8·05 years**



EXERCISE TRAINING

=

INVESTMENT IN MORE AND BETTER TIME

Figure 2: **Daily physical activity duration and all-cause mortality reduction**

Lancet 2011; 378: 1244-53

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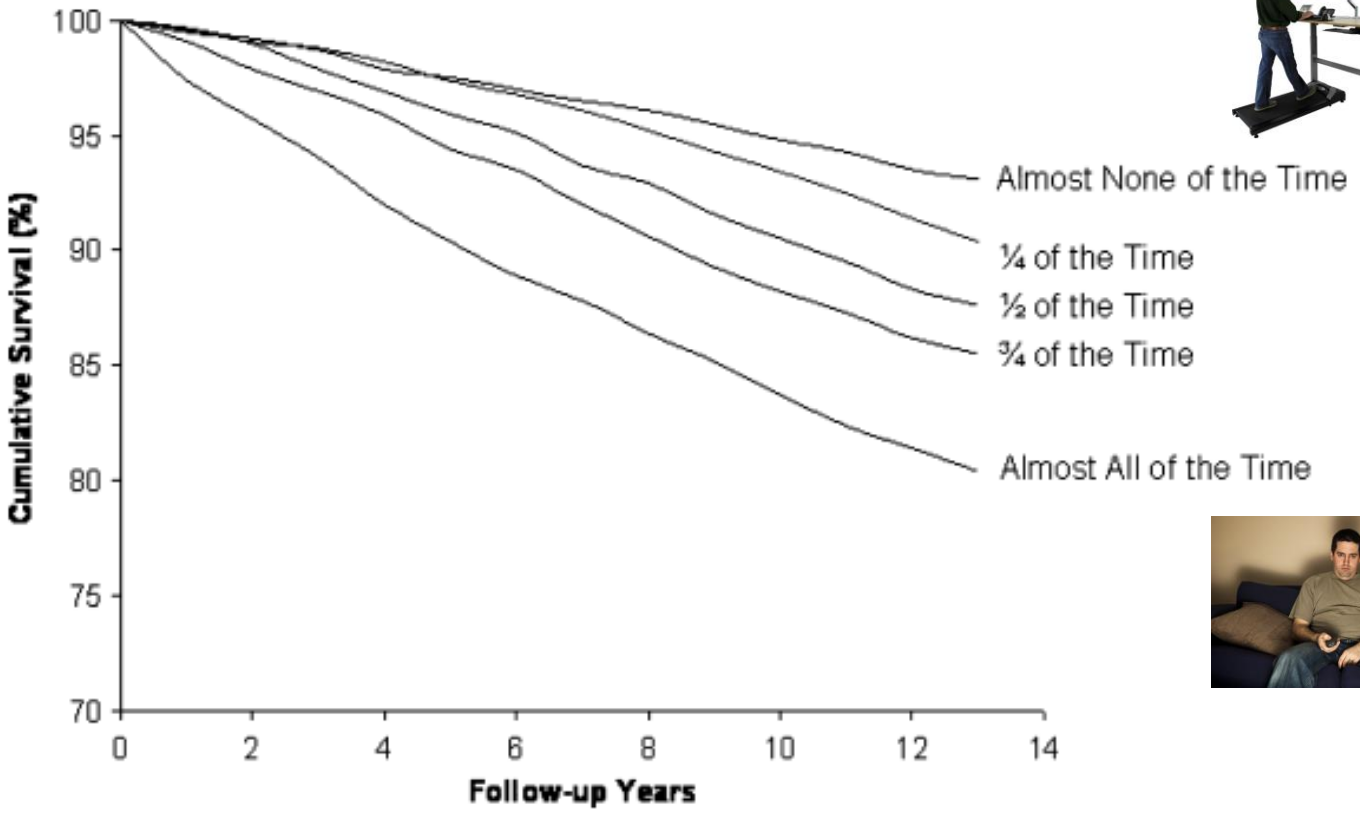
Exercise: why?

Leisure Time Spent Sitting in Relation to Total Mortality in a Prospective Cohort of US Adults

Alpa V. Patel*, Leslie Bernstein, Anusila Deka, Heather Spencer Feigelson, Peter T. Campbell, Susan M. Gapstur, Graham A. Colditz, and Michael J. Thun

184,190 participants

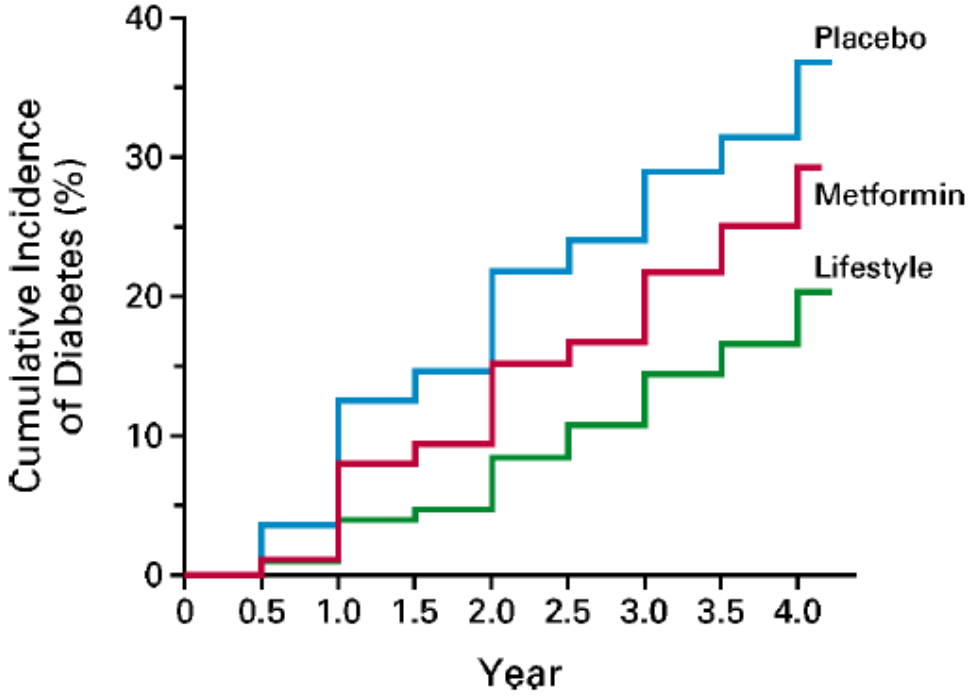


Am J Epidemiol 2010;172:419–429

Exercise in type 2 diabetes: why?

Prevention of type 2 diabetes

- 3234 glucose-intolerant subjects



Daily metformin intake = -33% T2DM incidence

Change in lifestyle = -58% T2DM incidence

Knowler et al. N Engl J Med 2002; 346: 393

Exercise in type 2 diabetes: why?

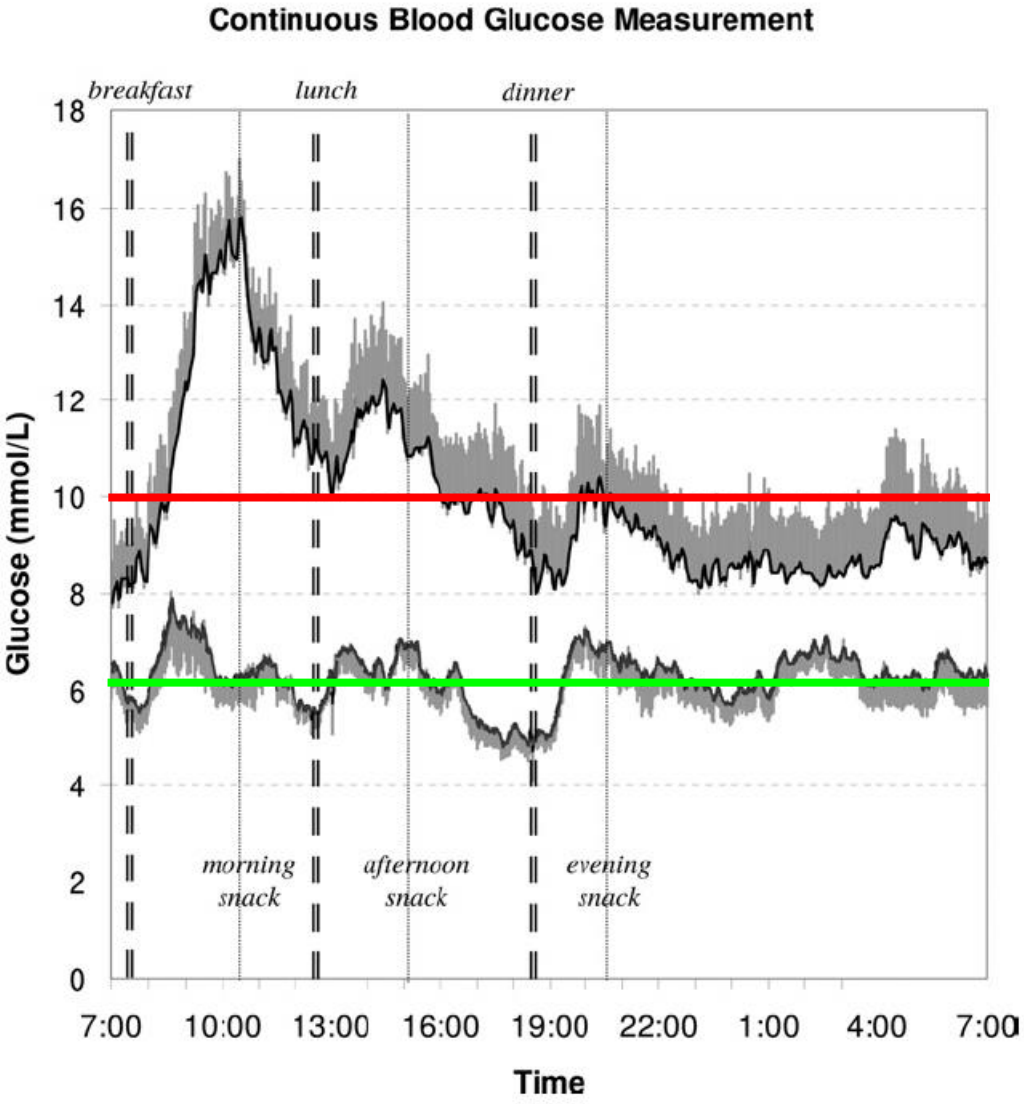
Prevention of type 2 diabetes

Through exercise training only?

37-49% risk reduction

Laaksonen DE, et al. Diabetes 2005; 54: 158-65

Exercise in type 2 diabetes: why?



13.30h hyperglycemic

0.4h hyperglycemic

Praet et al. Clin Sci 2006; 111: 119

Exercise in type 2 diabetes: why?

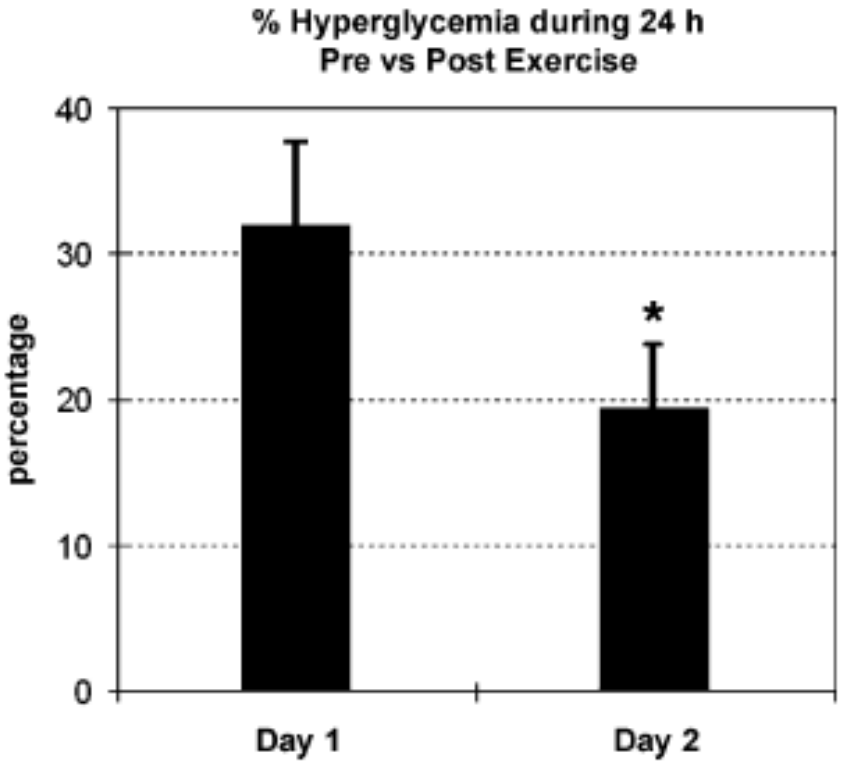


FIGURE 3—The duration of hyperglycemia, (i.e., percentage of time [glucose] above 10.0 mmol·L^{-1}), 24 h before and after 45 min of circuit training. Values are expressed as means ± SEM. * Significantly different from values observed on day 1 (preexercise) ($P < 0.05$).

Praet et al. Med Sci Sports Exerc 2006; 38: 2037

Exercise in type 2 diabetes: why?

Source	Number of participants: Walking	Number of participants: Control	WMD (95% CI) [%]	Weight, %
Supervised walking				
Belli *et al.* 2011	9	10	-1.30 (-2.72, 0.12)	2.94
Gram *et al.* 2010	22	22	-1.00 (-1.15, -0.85)	10.57
Kurban *et al.* 2011	30	30	-0.29 (-0.82, 0.24)	7.94
Negri *et al.* 2010	21	20	-0.11 (-0.47, 0.25)	9.28
Sung *et al.* 2012	22	18	-0.95 (-1.71, -0.19)	6.11
Ku *et al.* 2010	15	16	-0.50 (-1.17, 0.17)	6.75
Church *et al.* 2010	72	41	-0.31 (-0.56, -0.06)	10.04
Mitranun *et al.* 2014a	14	7	-0.60 (-2.09, 0.89)	2.74
Mitranun *et al.* 2014b	14	8	-1.00 (-2.33, 0.33)	3.21
Subtotal estimates (*P* = .001)			-0.58 (-0.93, -0.23)	59.58
Non-supervised walking				
Goldhaber-Fiebert *et al.* 2003	33	28	-1.40 (-2.56, -0.24)	3.87
Karstoft *et al.* 2013a	12	4	-0.20 (-1.22, 0.82)	4.54
Karstoft *et al.* 2013b	12	4	0.00 (-1.02, 1.02)	4.54
Shenoy *et al.* 2010	20	20	-1.00 (-1.55, -0.45)	7.75
van Rooijen *et al.* 2004	75	74	0.73 (-0.01, 1.47)	6.28
Arora *et al.* 2009	10	10	-0.75 (-1.54, 0.04)	5.93
Koo *et al.* 2010	13	18	-0.13 (-0.71, 0.45)	7.51
Subtotal estimates (*P* = .17)			-0.37 (-0.90, 0.15)	40.42
Overall estimates (*P* = .001)			-0.50 (-0.78, -0.21)	100.00

-2.0 -1.0 0 1.0 2.0

Decrease HbA1c Increase HbA1c

Qiu S, et al. PLoS One. 2014 Oct 17;9(10):e109767

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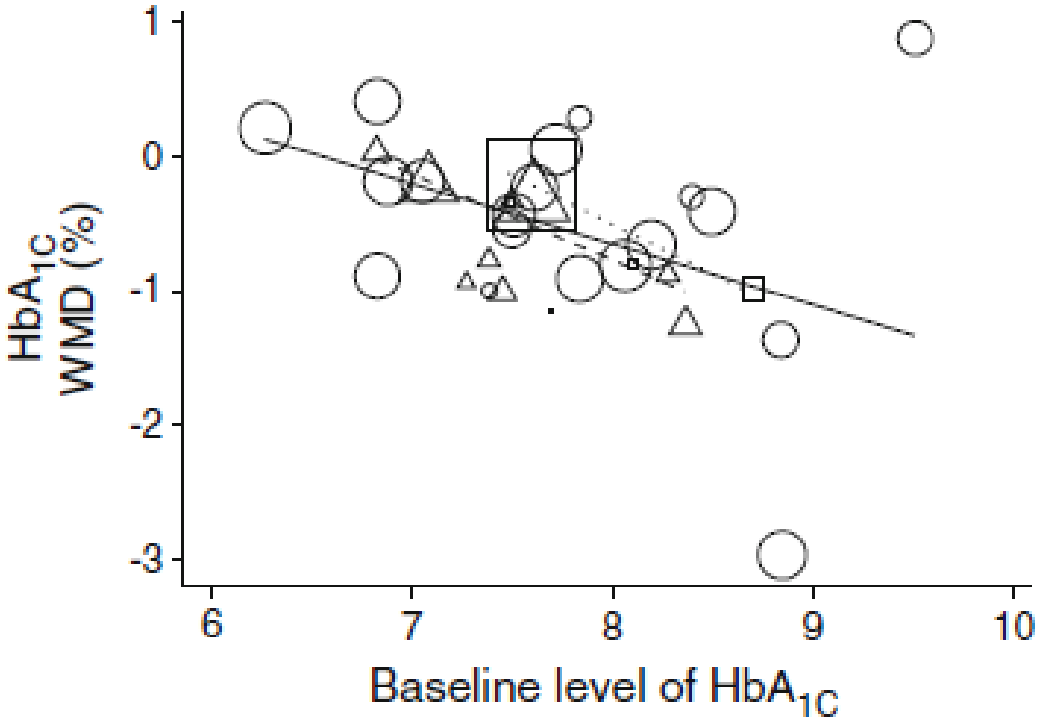
Exercise in type 2 diabetes: why?



Umpierre D, et al. Diabetologia 2013; 56: 242-51

Exercise in type 2 diabetes: why?

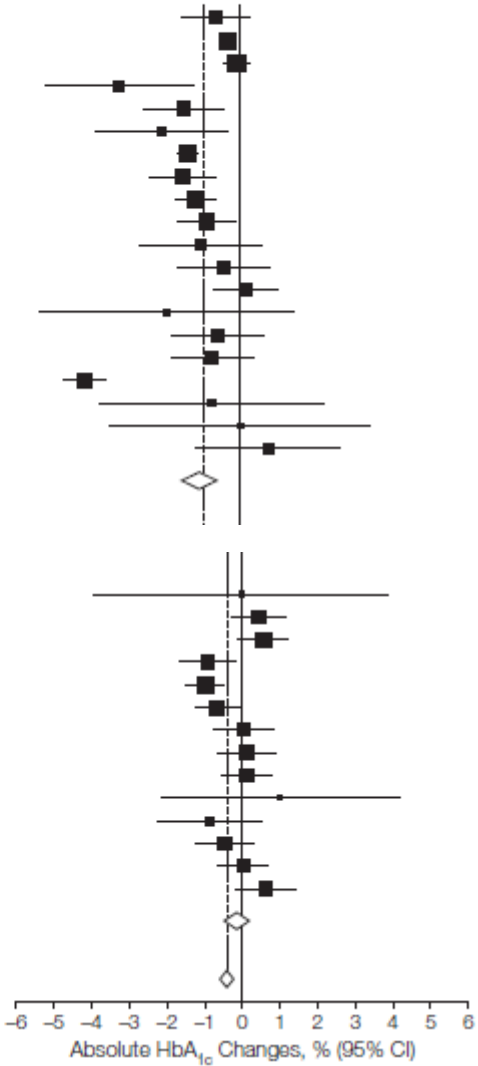
- Long-term exercise training in type 2 diabetes patients also positively affects:
  - Quality of life
  - Physical fitness
  - Inflammatory markers
  - Cardiovascular disease risk factors
    - Blood pressure, waist circumference, lipid profile

Umpierre D, et al. JAMA 2011; 305: 1790-99

Exercise in type 2 diabetes: why?

Figure 1. Absolute Changes in HbA_{1c} of Individual Studies of Structured Exercise Training vs No Intervention

Source	No. of Patients: Intervention	No. of Patients: Control	HbA_{1c} Weighted Mean Difference, % (95% CI)	Weight, %
Aerobic training				
Bjørgaas et al,[20] 2005	11	11	−0.44 (−1.03 to 0.15)	3.46
Church et al,[8] 2010	72	41	−0.23 (−0.30 to −0.16)	5.77
Cuff et al,[21] 2003	9	9	−0.07 (−0.28 to 0.14)	5.37
Dela et al,[22] 2004	14	10	−2.14 (−3.43 to −0.86)	1.38
Giannopoulou et al,[23] 2005	11	11	−1.00 (−1.70 to −0.30)	2.96
Goldhaber-Fiebert et al,[24] 2003	33	28	−1.40 (−2.56 to −0.24)	1.61
Kadoglou et al,[25] 2007	29	27	−0.93 (−1.08 to −0.78)	5.57
Kadoglou et al,[26] 2007	28	26	−1.02 (−1.59 to −0.45)	3.55
Kadoglou et al,[27] 2010[a]	22	21	−0.80 (−1.15 to −0.45)	4.68
Kadoglou et al,[27] 2010[b]	23	23	−0.59 (−1.11 to −0.07)	3.81
Lambers et al,[28] 2008	18	11	−0.70 (−1.78 to 0.38)	1.78
Ligtenberg al,[29] 1997	25	26	−0.30 (−1.11 to 0.51)	2.57
Middlebrooke et al,[30] 2006	22	30	0.10 (−0.45 to −0.65)	3.64
Raz et al,[31] 1994	19	19	−0.30 (−3.53 to 0.93)	0.54
Ribeiro et al,[32] 2008	11	10	−0.40 (−1.19 to 0.39)	2.61
Sigal et al,[7] 2007	60	63	−0.50 (−1.22 to 0.22)	2.88
Sridhar et al,[33] 2010	55	50	−2.76 (−3.13 to −2.39)	4.60
Vancea et al,[34] 2009[c]	14	17	−0.50 (−2.47 to 1.47)	0.68
Vancea et al,[34] 2009[d]	9	17	0.00 (−2.30 to 2.30)	0.51
Verity and Ismail,[35] 1989	5	5	0.50 (−0.75 to 1.75)	1.43
All aerobic training I^2 = 92.8%; *P* for heterogeneity <.001			−0.73 (−1.06 to −0.40)	59.41
Physical activity advice alone				
Brun et al,[53] 2008	13	12	−0.04 (−3.93 to 3.85)	0.16
Cheung et al,[54] 2009	20	17	0.40 (−0.29 to −1.09)	3.49
Diedrich et al,[55] 2010	27	26	0.54 (−0.11 to 1.19)	3.82
Kim and Kang,[56] 2006[a]	22	23	−0.94 (−1.68 to −0.20)	3.19
Kim and Kang,[56] 2006[b]	28	23	−1.02 (−1.51 to −0.53)	5.28
Kirk et al,[57] 2003	26	31	−0.68 (−1.26 to −0.10)	4.40
Kirk et al,[58] 2009[c]	47	35	0.00 (−0.79 to 0.79)	2.88
Kirk et al,[58] 2009[d]	51	35	0.10 (−0.65 to 0.85)	3.13
Krousel-Wood et al,[59] 2008	37	39	0.10 (−0.56 to 0.76)	3.71
Leehey et al,[60] 2009	7	4	1.00 (−2.16 to 4.16)	0.24
Rönnemaa et al,[61] 1986	13	12	−0.90 (−2.25 to 0.45)	1.20
Samaras et al,[62] 1997	13	13	−0.49 (−1.24 to 0.26)	3.10
Tudor-Locke et al,[63] 2004	24	23	0.00 (−0.66 to 0.66)	3.72
van Rooijen et al,[64] 2004	75	74	0.62 (−0.14 to 1.38)	3.09
All advice alone I^2 = 61.2%; *P* for heterogeneity = .001			−0.16 (−0.50 to 0.18)	41.40
Overall I^2 = 62.9%; *P* for heterogeneity <.001			−0.43 (−0.59 to −0.28)	100.00



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KineCoach project

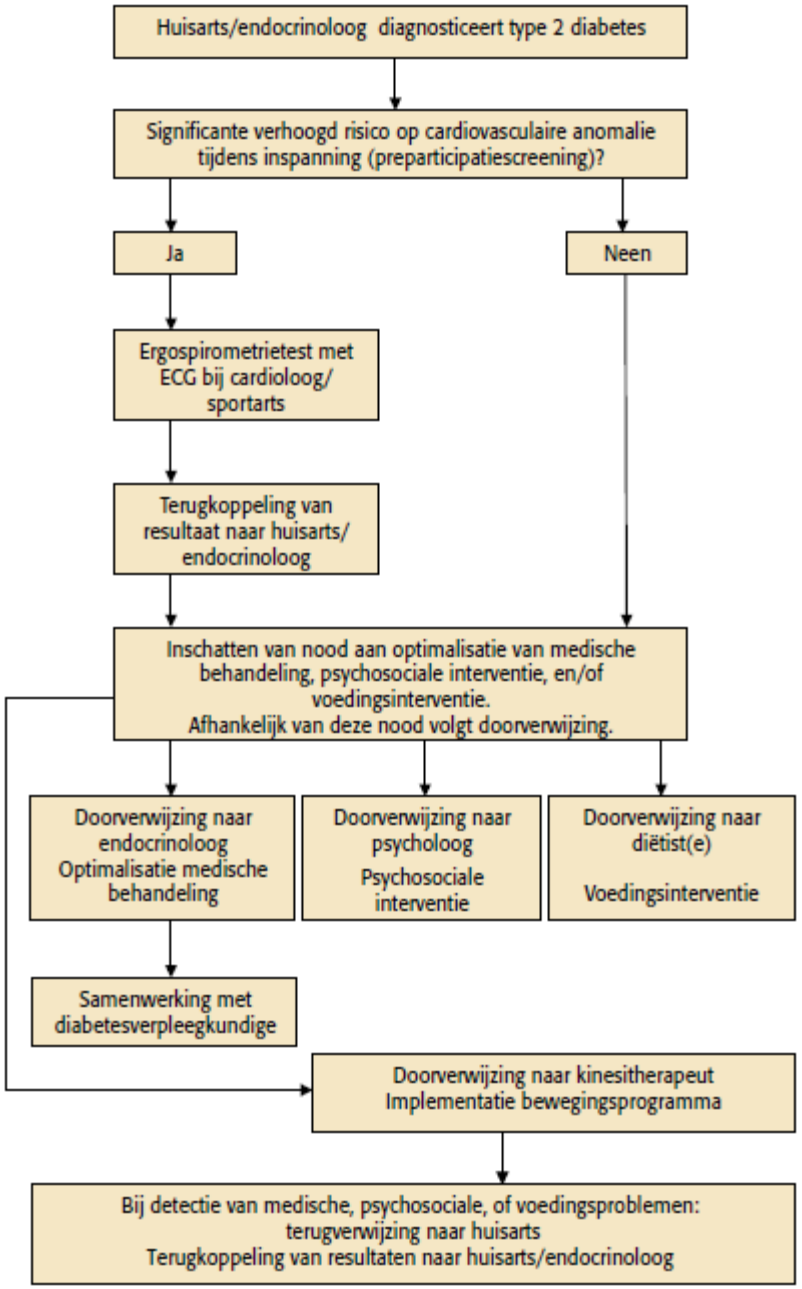
- Prevalence of T2DM is rapidly rising
- T2DM is associated with many co-morbidities
- Exercise intervention is highly effective
- GP's, cardiologists and endocrinologists often promote a healthy lifestyle to their patients
- But where can these patients follow medically safe and clinically effective exercise interventions?

KineCoach pr

KineCoach: nationaa bewegingsprogramm

DIABETES & BEWEGING

Figuur 1: Stappenplan bij het opzetten van bewegingsprogramma's voor personen met type 2 diabetes.



Hansen D, et al. Vlaams Tijdschr Diabetol 2013; 1: 10-12

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KNOWLEDGE IN ACTION

KineCoach project

Physical Therapy
Journal of the American Physical Therapy Association

Exercise Assessment and Prescription in Patients With Type 2 Diabetes in the Private and Home Care Setting: Clinical Recommendations From AXXON (Belgian Physical Therapy Association)

Dominique Hansen, Stefaan Peeters, Bruno Zwaenepoel, Dirk Verleyen, Carla Wittebrood, Nicole Timmerman, Michel Schotte

Hansen D, et al. Phys Ther 2013; 93: 597-610

KineCoach project

Step	Measures
Step 1: Preparticipation screening	
General medical risk	• PAR-Q (further examination on positive outcomes)
Specific medical risk	• Cardiovascular, neurologic (peripheral and autonomic), and orthopedic screening: refer to physician in case of severe or previously undetected anomalies • Screening of nephropathy and retinopathy is not feasible: medical history/records should be examined • Refer to physician in case of: untreated hypertension (blood pressure >140/90 mm Hg), angina pectoris, previously undetected heart rhythm disturbances, untreated intermittent claudication, fasting hyperglycemia (blood glucose level >16.8 mmol/L, >300 mg/dL), frequent hypoglycemic episodes, untreated wounds in lower extremities, cachexia or sudden body weight loss, untreated autonomic or peripheral neuropathy, or untreated vision disturbances
Glycemic control	• Laboratory values (glucose, HbA_{1c}) • Medication treatment (biguanide, sulfonylurea, insulin, alfa-glucosidase inhibitor, bile acid sequestrant, meglitinide, DDP-4 inhibitor, thiazolidinedione, dopamine agonist, GLP-1 receptor agonist, blood pressure and cholesterol lowering medication, and anticoagulation)
Health parameters	• Fall risk (TUG, DGI) • Physical activity level (pedometer/accelerometer) • Body composition (bioelectrical impedance, waist circumference) • Endurance exercise capacity (Astrand-Rhyming cycling test, 6MWT) • Muscle strength (handgrip strength test)
Consider patient motivation to exercise	

Hansen D, et al. Phys Ther 2013; 93: 597-610

KineCoach project

Step 2: Increase medical safety during exercise training	
Take cardiovascular, neurologic, nephrologic, retinal, and orthopedic comorbidities into account before initiating exercise training	
Optimize glycemic control	• Check blood glucose level before and after exercise training (should be 4.2–16.7 mmol/L, 75–300 mg/dL) • Lower medication/insulin therapy in case of low blood glucose level (<4.2 mmol/L, <75 mg/dL) or symptoms of hypoglycemia before exercise training • Elevate carbohydrate intake in case of low blood glucose level (<5.5 mmol/L, <100 mg/dL) or symptoms of hypoglycemia before exercise training • Adjust training modalities (lower total exercise energy expenditure in case of low blood glucose level or symptoms of hypoglycemia; do not execute high-intensity exercise in case of blood glucose level >16.7 mmol/L, >300 mg/dL)
Optimize cardiovascular safety	• Assess resting (60–100 bpm) and exercise (rate and rhythm) heart rate • Assess blood pressure at start and end of exercise session (<140/90 mm Hg)
Optimize general medical safety	• Retinopathy: avoid high-intensity exercise (>80% $\dot{V}o_2max$) • Nephropathy: avoid hypertension (systolic blood pressure >180 mm Hg) during exercise • Fever: postpone exercise training until body temperature is restored • Peripheral neuropathy (with foot wound): avoid weight-bearing exercises • Pregnancy: refer to gynecologist • Autonomic neuropathy: regularly check heart rate and blood pressure • Refer to physician when: development or worsening of hypertension, angina pectoris, heart rhythm disturbances, development or worsening of resting tachycardia, development or worsening of intermittent claudication, development or worsening of fasting hyperglycemia, frequent hypoglycemic episodes, development or worsening of wounds in lower extremities, cachexia, autonomic neuropathy, or development or worsening of vision disturbances

Hansen D, et al. Phys Ther 2013; 93: 597-610

KineCoach project

Step 3: Optimize exercise training intervention	
	• 3–5 days of exercise per week • Combine endurance training with strength training • Low to moderate endurance exercise intensities are effective (50%–75% $\dot{V}o_2max$) • Achieve a minimal exercise duration >150 minutes/week • Strength exercise modalities: 5–10 exercises/session, 3 series/exercise, 10–15 repetitions/series • Aim at permanent increase in physical activity level • In case of obesity: increase exercise volume or caloric expenditure (to 250 minutes/week) • In case of sarcopenia or low muscle strength: elevate strength training volume • Base exercise intensity on heart rate reserve • Evaluate blood HbA_{1c} content (goal <6.5%) to assess impact of exercise intervention

Hansen D, et al. Phys Ther 2013; 93: 597-610

Exercise interventions in type 2 diabetes

Your Prescription for Health

ExeRcise is Medicine™

www.ExerciseIsMedicine.org

Exercise interventions in type 2 diabetes

- How to prescribe exercise?

- Adapt the exercise modalities!
  - Exercise intensity
  - Session duration
  - Exercise frequency
  - Program duration
  - Addition of strength-training

Exercise intensity

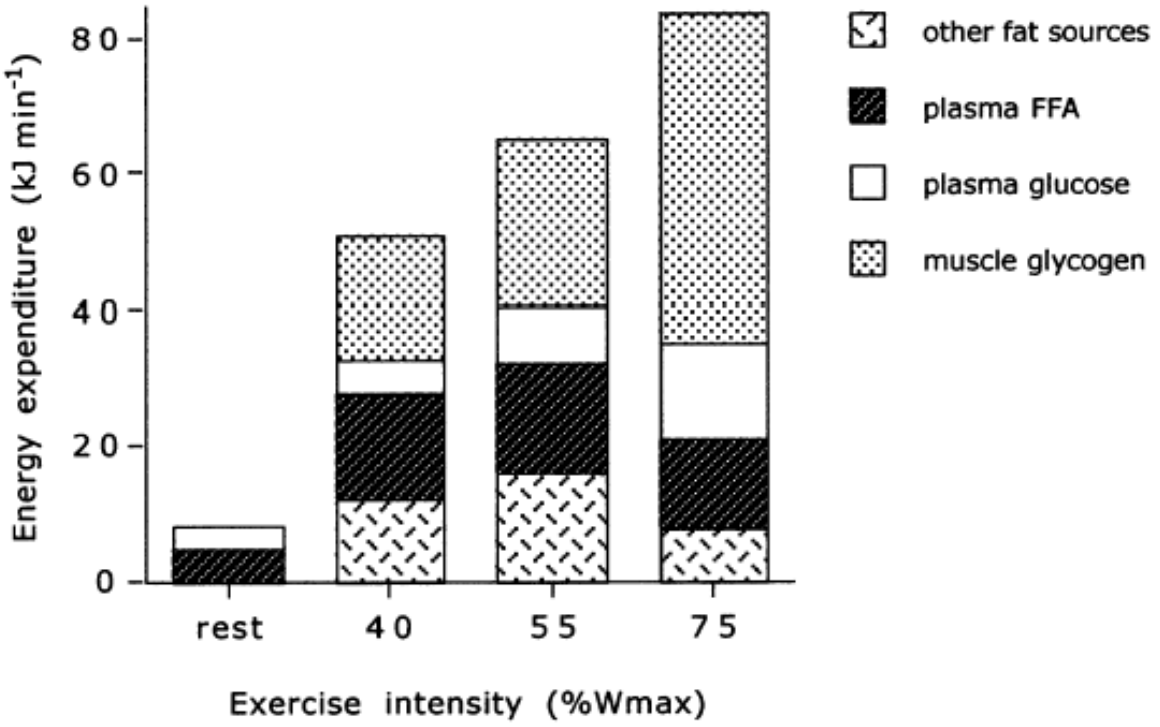
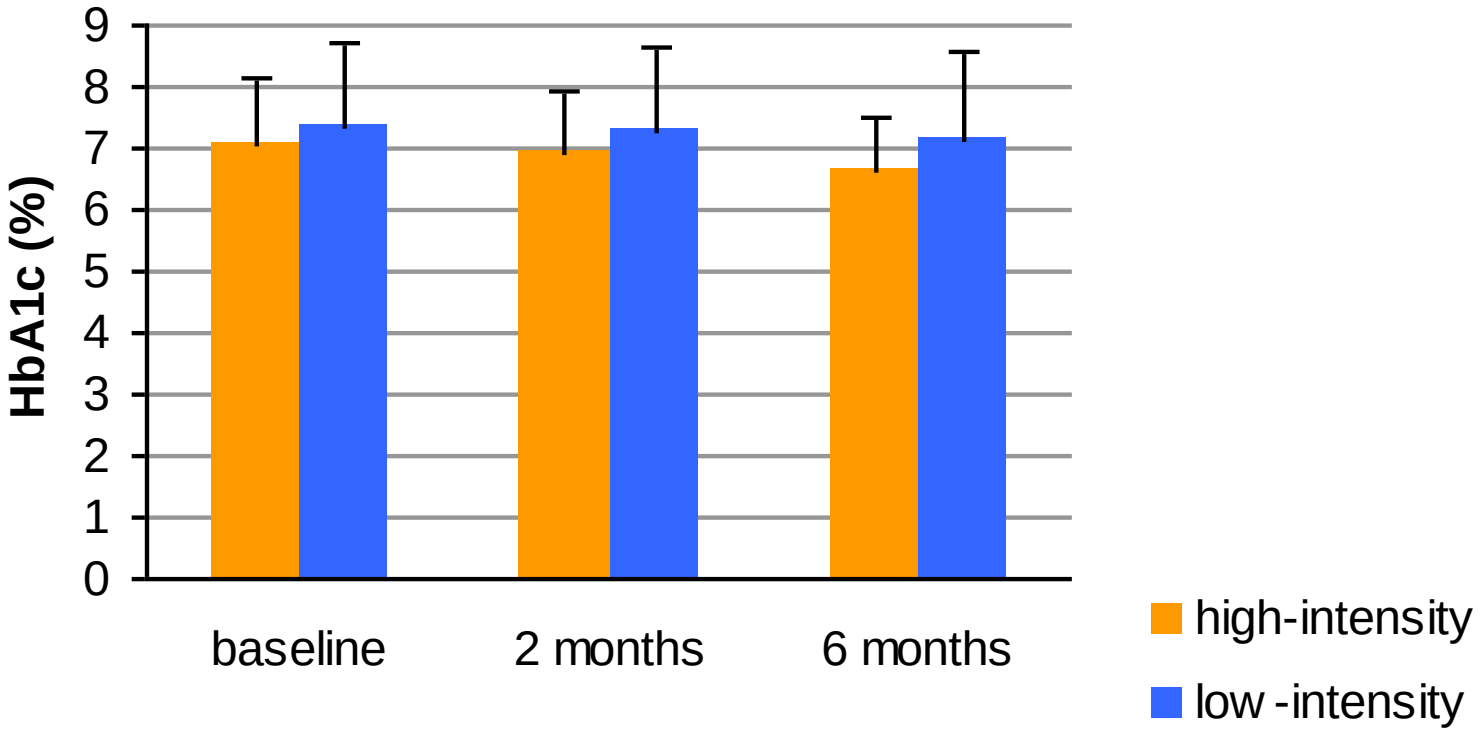


Figure 4. Energy expenditure and fuel selection
Values are means. FFA, free fatty acid.

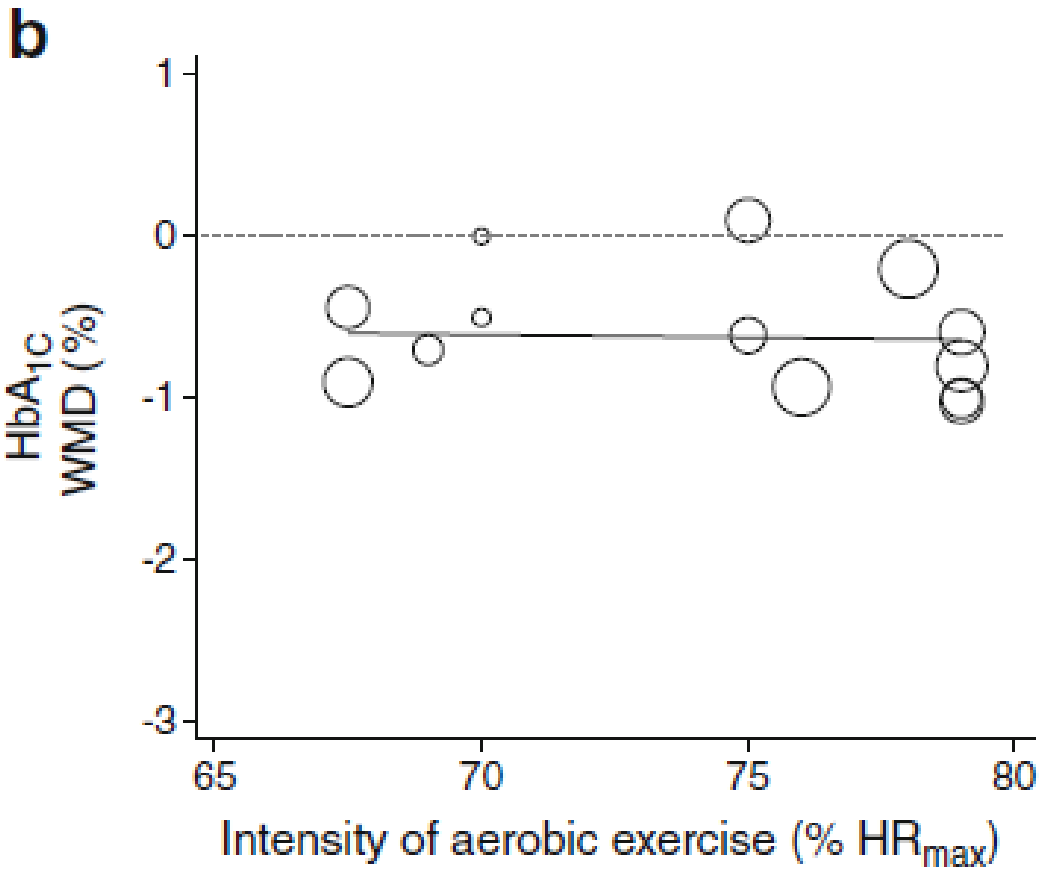
Van Loon LJ, et al. J Physiol 2001; 536: 295

Exercise intensity



Hansen D, et al. Diabetologia 2008: 52: 1789-97

Exercise intensity



Umpierre D, et al. Diabetologia 2013; 56: 242-51

Exercise intensity

	SED (n = 15)		CON (n = 14)		INT (n = 14)	
	Pre	Post	Pre	Post	Pre	Post
Fasting blood glucose (mmol/L)	7.38 ± 22	7.27 ± 20	7.65 ± 28	6.66 ± 20*	7.65 ± 22	6.60 ± 23*
Insulin resistance (HOMA)	3.9 ± 1.2	4.2 ± 1.4	2.8 ± 1.3	2.3 ± 1.5*†	3.1 ± 1.4	2.5 ± 1.1*†
HbA_{1c} (mmol/mol)	62 ± 2	65.1 ± 2	61 ± 2	59 ± 3	60 ± 2	54 ± 2*†
Total cholesterol (mmol/L)	5.12 ± 15	5.38 ± 14	4.71 ± 15	4.61 ± 15	4.89 ± 18	4.40 ± 18*
HDL cholesterol (mmol/L)	1.11 ± 5	1.16 ± 4	1.37 ± 4	1.45 ± 5†	1.06 ± 4	1.37 ± 5*†
LDL cholesterol (mmol/L)	3.49 ± 15	3.34 ± 14	3.41 ± 15	2.84 ± 14*	3.34 ± 15	2.61 ± 14*
Triglyceride (mmol/L)	1.80 ± 21	1.75 ± 20	1.63 ± 19	1.57 ± 20	1.66 ± 20	1.46 ± 19
Malondialdehyde (μmol/L)	1.34 ± 0.06	1.33 ± 0.1	1.36 ± 0.07	1.21 ± 0.14	1.56 ± 0.07	1.03 ± 0.07*†
Glutathione peroxidase (U/g Hb)	85.8 ± 4.0	81.3 ± 5.8	96.6 ± 5.3	99.4.2 ± 3.6†	89.9 ± 5.0	112.2 ± 7.3*#
Superoxide dismutase (U/g Hb)	2883 ± 82	2617 ± 70	2815 ± 65	2725 ± 76	2813 ± 88	2762 ± 77
Nitric oxide (nmol)	0.73 ± 0.23	1.16 ± 0.2	0.92 ± 0.20	0.82 ± 0.15†	0.71 ± 0.20	1.47 ± 0.18*†#
von Willebrand factor (%)	121.5 ± 14.4	131.3 ± 16.7	125.7 ± 18.9	117.0 ± 12.5	129.6 ± 20.1	83.0 ± 16.9*†#

Data are means ± standard error of the mean.

*$P < 0.05$ vs Pre; †$P < 0.05$ vs SED; #$P < 0.05$ vs CON.

SED, sedentary control; CON, continuous aerobic exercise training; INT, interval aerobic exercise training; HOMA, homeostasis model assessment; HDL, high-density lipoprotein; LDL, low-density lipoprotein.

Mitranun W, et al. Scand J Med Sci Sport 2013; e-pub ahead of print

Session duration/volume

- Assumption
  - Longer exercise sessions = greater effect
    - Greater decrease in plasma glucose levels in T2DM patients when cycling for 40 minutes at 70% VO_{2peak} compared with 40 minutes at 50% VO_{2peak}

Sriwijitkamol A, et al. Diabetes 2007; 56: 836-48

Program duration

- International guidelines
  - Minimal 2 months in order to detect clinical benefits
  - Elevated physical activity should be sustained after supervised program completion

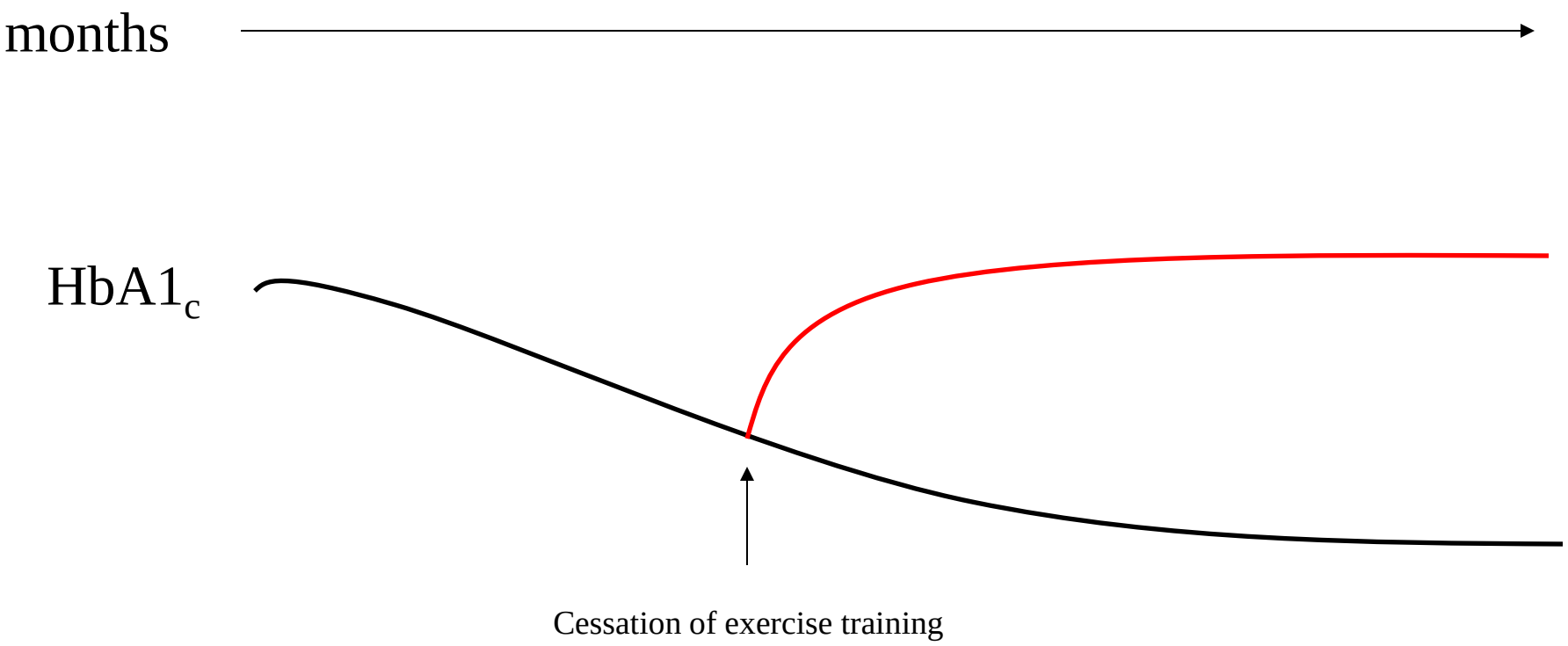
Program duration

Table I. Impact of training programme duration on clinical benefits of exercise training

Study	Age (years)	No. of subjects	Subject characteristics	Effect parameter	Comparison	Effect
Lehmann et al.[88]	54	16	T2DM patients	HbA_{1c}	12 vs 24 weeks (repeated assessment)	No effect found
Saltin et al.[89]	48	25	T2DM patients	AUC during OGTT	12 vs 24 weeks (repeated assessment)	No further reduction after 12 weeks of intervention
Bourn et al.[90]	NA	20	T2DM patients	HbA_{1c}	Repeated assessment during 104 weeks	Ceased to decrease after 84 weeks of intervention
Uusitupa[91]	NA	18	T2DM patients	HbA_{1c}	12 vs 60 weeks (repeated assessment)	Reduced more with longer duration
Tokmakidis et al.[92]	55	9	T2DM patients	AUC during OGTT	4 vs 16 weeks (repeated assessment)	Reduced more with longer duration

Hansen D, et al. Sports Med 2010: 40: 921

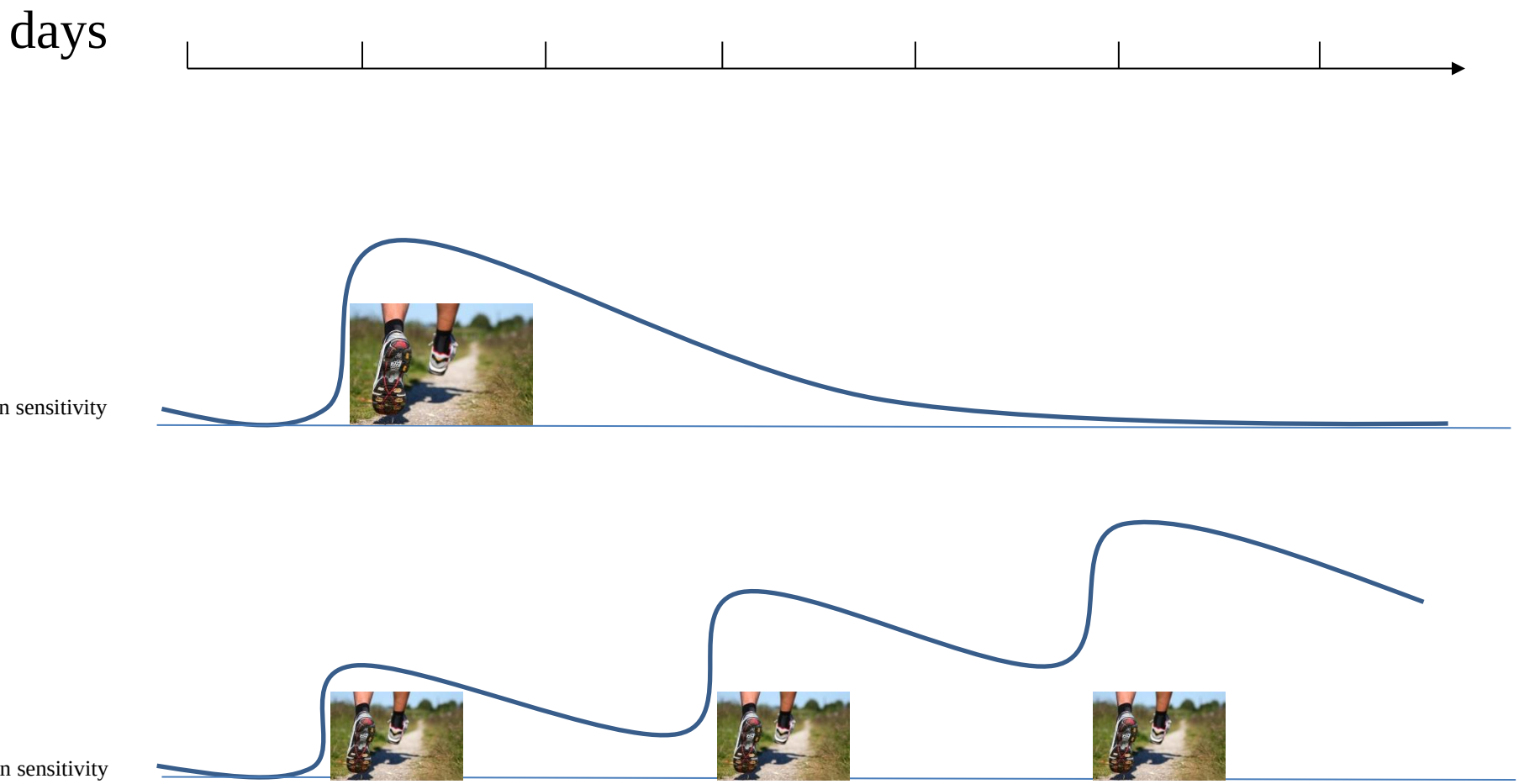
Program duration



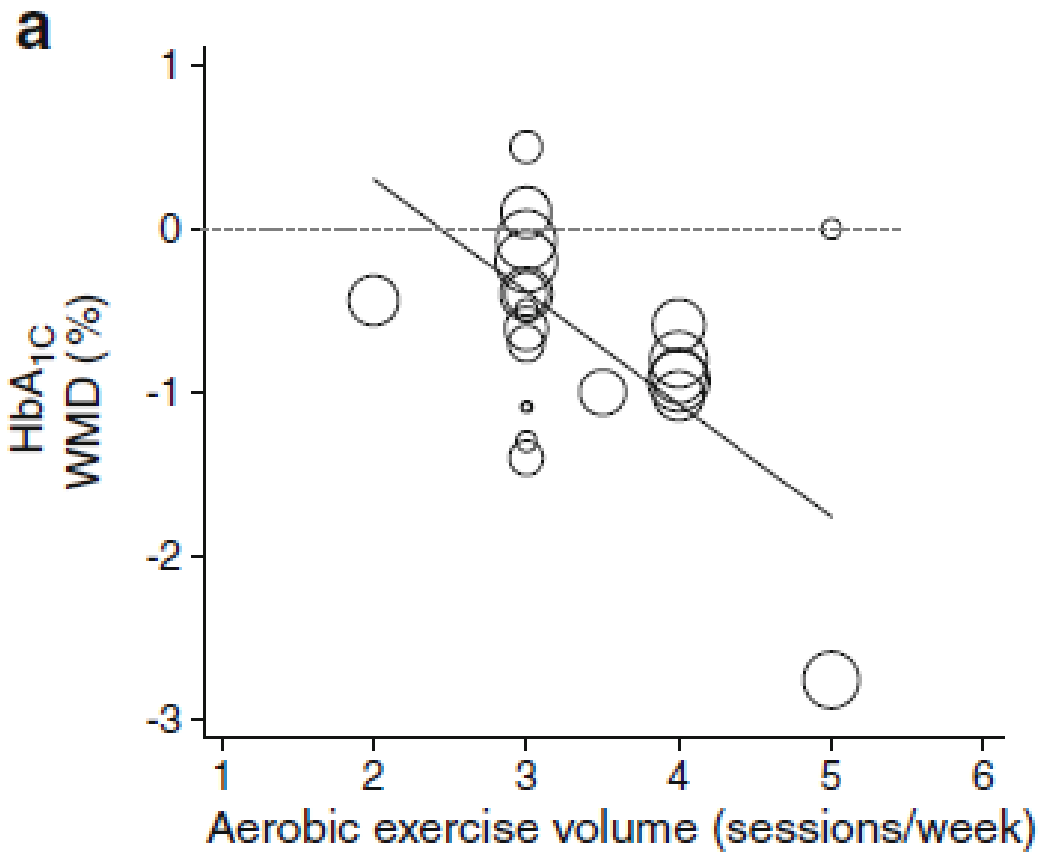
Exercise frequency

- International guidelines
  - 3 to 5 d/week
    - At start of programme: 3 days
    - After 4-6 months of exercise training: increase training frequency
  - On a regular base!

Exercise frequency



Exercise frequency

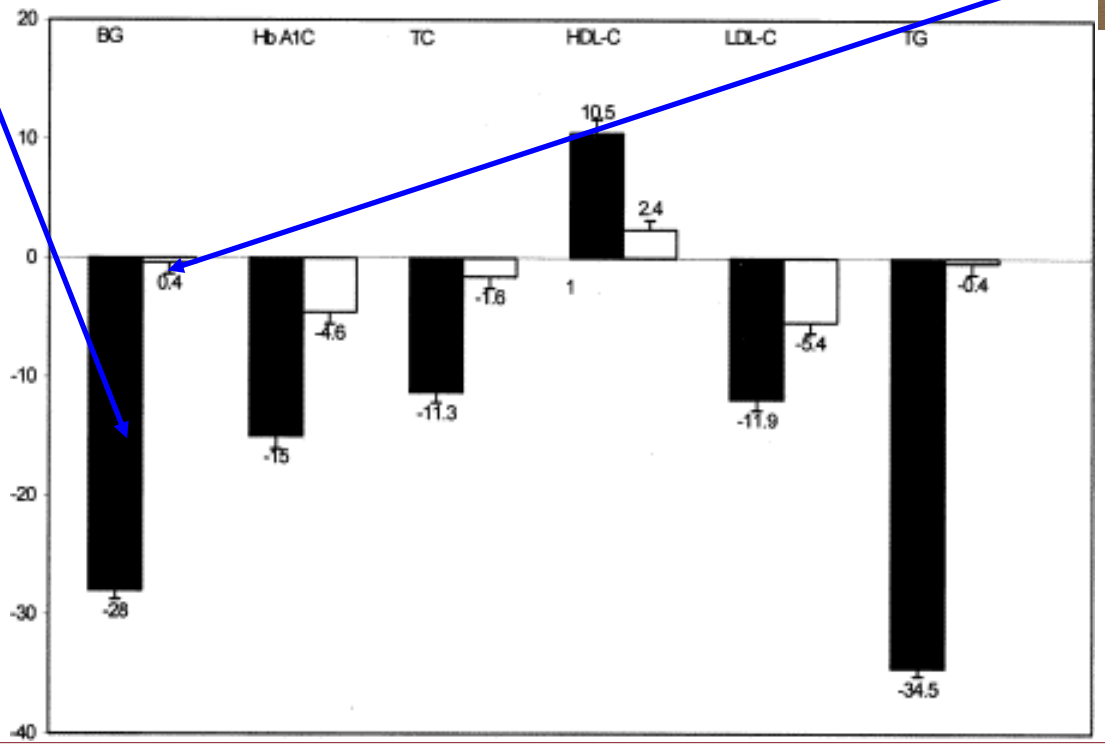


Umpierre D, et al. Diabetologia 2013; 56: 242-51

Addition of strength exercises

- International guidelines
  - Strength training exercises should be added:
    - 10-15 reps, 3 series, 65-70% 1RM

Addition of strength exercises



Cauza et al. Arch Phys Med Rehabil 2005; 86: 1527

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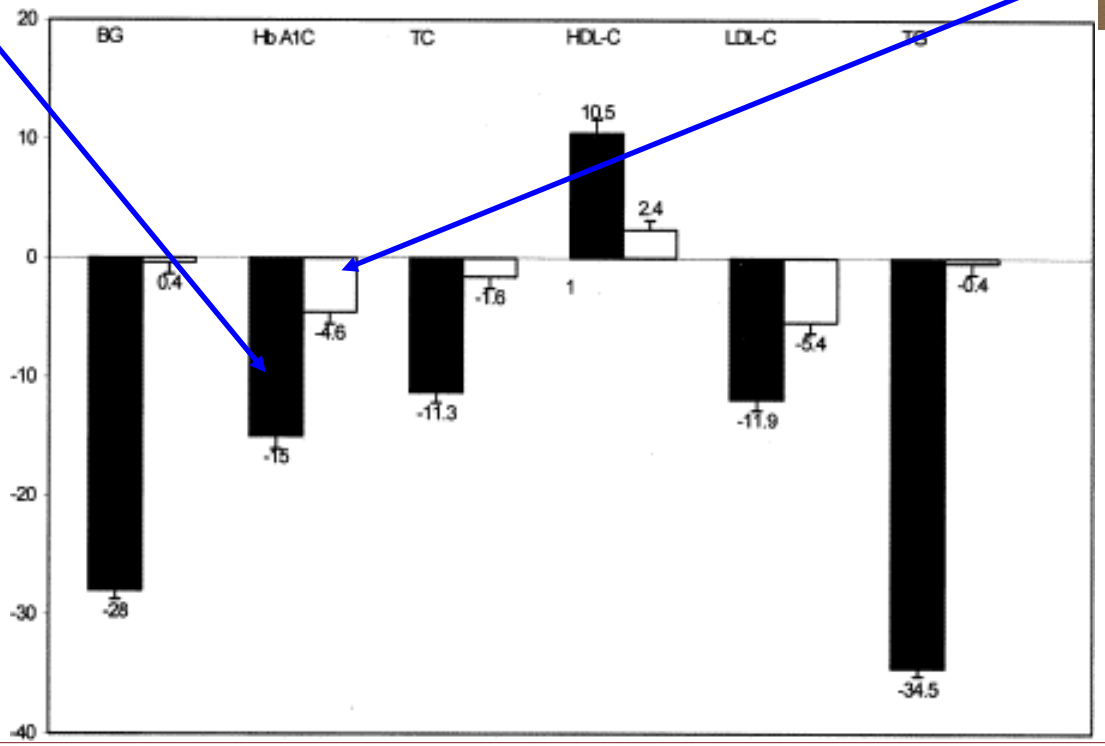
Addition of strength exercises



Cauza et al. Arch Phys Med Rehabil 2005; 86: 1527

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Addition of strength exercises

Table II. Impact of the addition of resistance-type exercises on clinical benefits of endurance-type exercise training

Study	Age (years)	No. of subjects	Subject characteristics	Effect parameter	Comparison	Effect
Cuff et al.[50]	63 vs 59	10 vs 9	T2DM patients	Glucose infusion rate	Endurance vs endurance + strength	Greater increase of glucose infusion rate
Sigal et al.[42]	53 vs 54	64 vs 60	T2DM patients	HbA_{1c}	Endurance vs endurance + strength	Greater reduction of HbA_{1c}

Hansen D, et al. Sports Med 2010: 40: 921

How to maximize medical safety

Increase the medical safety of intervention in following conditions:

- Peripheral neuropathy and/or delayed wound healing = be alert to wounds and/or peripheral sensation disturbances
- Autonomic neuropathy = be alert to deregulated blood pressure
- Cardiovascular disease = rule out coronary and/or peripheral vascular disease
- Retinopathy = no high-intensity exercises
- Nephropathy = avoid high blood pressures

ACSM & ADA. Med Sci Sports Exerc 2010; 42: 2282-303

How to maximize medical safety

- Orthopedic screening
  - Diabetic hand syndrome
  - Dupuytren contracture
  - Trigger finger
  - Diffuse idiopathic skeletal hyperostosis
  - Charcot foot

How to maximize medical safety

- Check feet
  - Shoes: worn out or too narrow?
  - Feet: dermatologic risk factors

How to maximize medical safety

Glycemic control

- Start training session
  - Glucose <75 mg/dl: consume monosaccharides
  - Glucose <100 mg/dl: be alert for hypoglycemia
  - Glucose >300 mg/dl: rule out keto-acidosis, no high-intensity exercise
- Risk factors for hypoglycemia during exercise
  - Prolonged (>60 min), and/or intense exercise
  - Exercise in fasting condition?
  - Medication: sulfonyloreas, meglitinide, exogeneous insulin therapy
- During follow-up
  - Regularly assess blood glucose content
  - Always carry monosacharides with you
  - Exercise in group

ACSM & ADA. Med Sci Sports Exerc 2010; 42: 2282-303

How to maximize medical safety

- Check prescribed medication
  - Cardioprotective drugs
    - Diuretics
      - Dehydration and electrolyte imbalances when dosed too high
    - Beta-blockers
      - Lowering in exercise HR
      - Lowers sensation of hypoglycemia
    - Lipid-lowering medication
      - Statins could lead to myopathies

How to maximize medical safety

Adjustments of Exogenous Insulin Therapy Dose Ahead of Exercise Training[69]

Duration and Type of Exercise	Glycemia Pre-exercise	Insulin Adjustment Pre-exercise	Extra Glucose Intake During Exercise
<30 min low-intensity exercise	<5 mmol/L, <90 mg/dL	Half dose	10–15 g
	>5 mmol/L, >90 mg/dL	Normal dose	None
30–60 min moderate-intensity exercise	<5 mmol/L, <90 mg/dL	Skip	30–45 g
	5–10 mmol/L, 90–180 mg/dL	Half dose	15 g
	>10 mmol/L, >180 mg/dL	Normal dose	None
>60 min moderate-intensity exercise	<5 mmol/L, <90 mg/dL	Skip	45 g/h
	5–10 mmol/L, 90–180 mg/dL	Half dose	30–45 g/h
	>10 mmol/L, >180 mg/dL	Half dose	15 g/h

Hansen D, et al. Phys Ther 2013; 93: 597-610

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