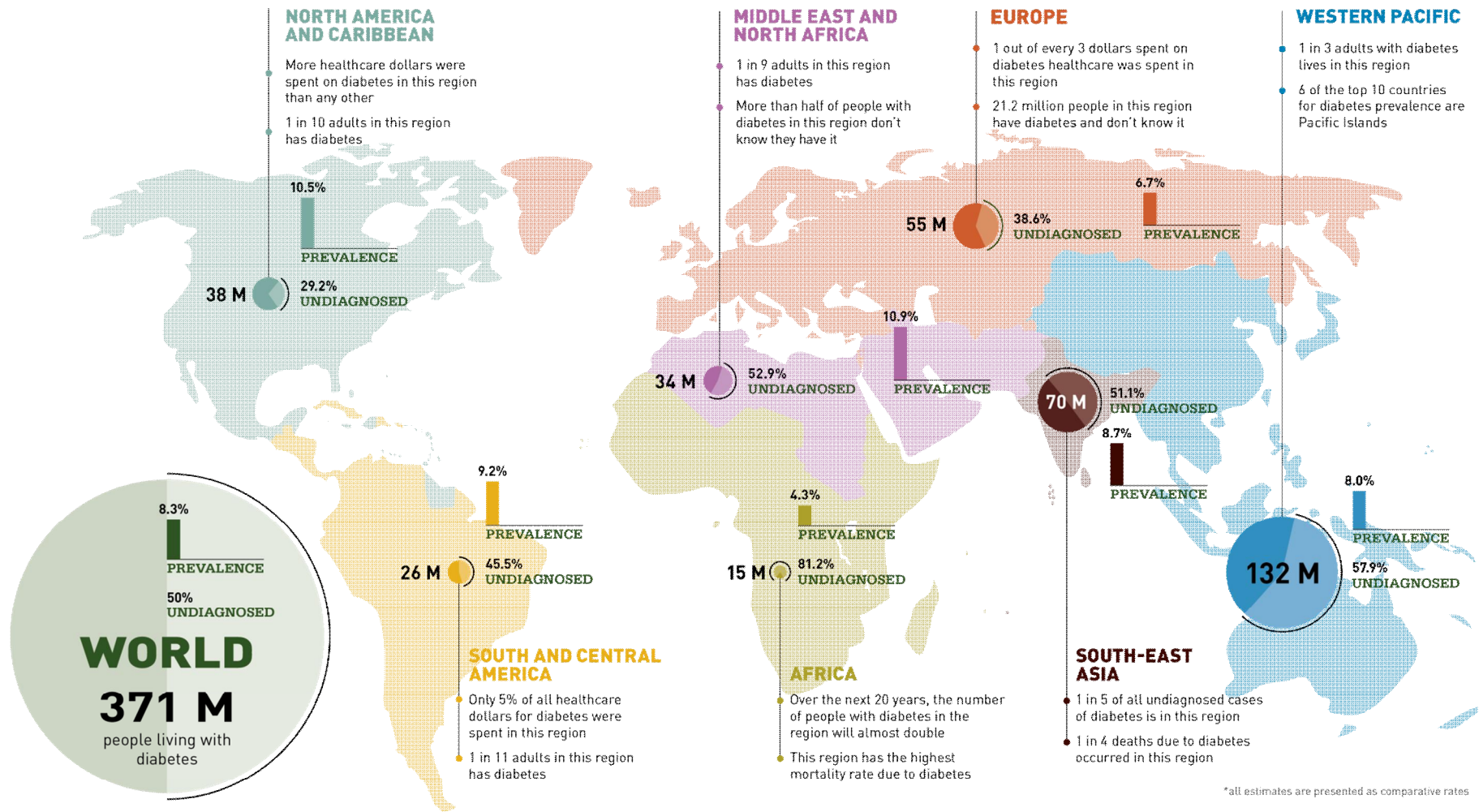# Physical activity and the prevention and treatment of diabetes

Dr Jason Gill

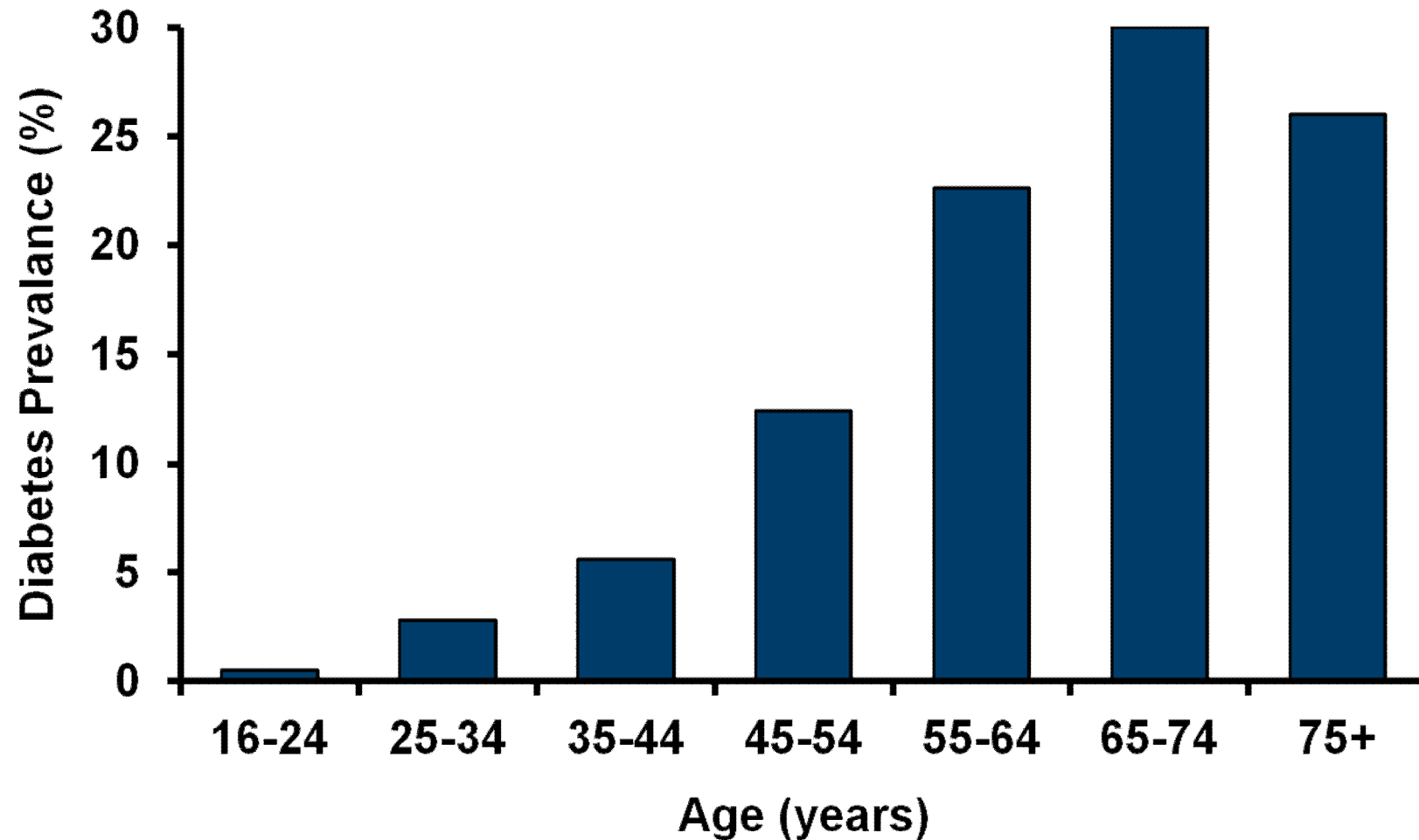Institute of Cardiovascular and Medical Sciences
University of Glasgow

NORTH AMERICA AND CARIBBEAN

More healthcare dollars were spent on diabetes in this region than any other

1 in 10 adults in this region has diabetes

10.5%
PREVALENCE

38 M
29.2% UNDIAGNOSED

MIDDLE EAST AND NORTH AFRICA

1 in 9 adults in this region has diabetes

More than half of people with diabetes in this region don't know they have it

34 M
52.9% UNDIAGNOSED

10.9%
PREVALENCE

EUROPE

1 out of every 3 dollars spent on diabetes healthcare was spent in this region

21.2 million people in this region have diabetes and don't know it

55 M
38.6% UNDIAGNOSED

6.7%
PREVALENCE

WESTERN PACIFIC

1 in 3 adults with diabetes lives in this region

6 of the top 10 countries for diabetes prevalence are Pacific Islands

8.0%
PREVALENCE

132 M
57.9% UNDIAGNOSED

70 M
51.1% UNDIAGNOSED

8.7%
PREVALENCE

SOUTH-EAST ASIA

1 in 5 of all undiagnosed cases of diabetes is in this region

1 in 4 deaths due to diabetes occurred in this region

4.3%
PREVALENCE

15 M
81.2% UNDIAGNOSED

AFRICA

Over the next 20 years, the number of people with diabetes in the region will almost double

This region has the highest mortality rate due to diabetes

9.2%
PREVALENCE

26 M
45.5% UNDIAGNOSED

SOUTH AND CENTRAL AMERICA

Only 5% of all healthcare dollars for diabetes were spent in this region

1 in 11 adults in this region has diabetes

8.3%
PREVALENCE

50% UNDIAGNOSED

WORLD
371 M
people living with diabetes

*all estimates are presented as comparative rates
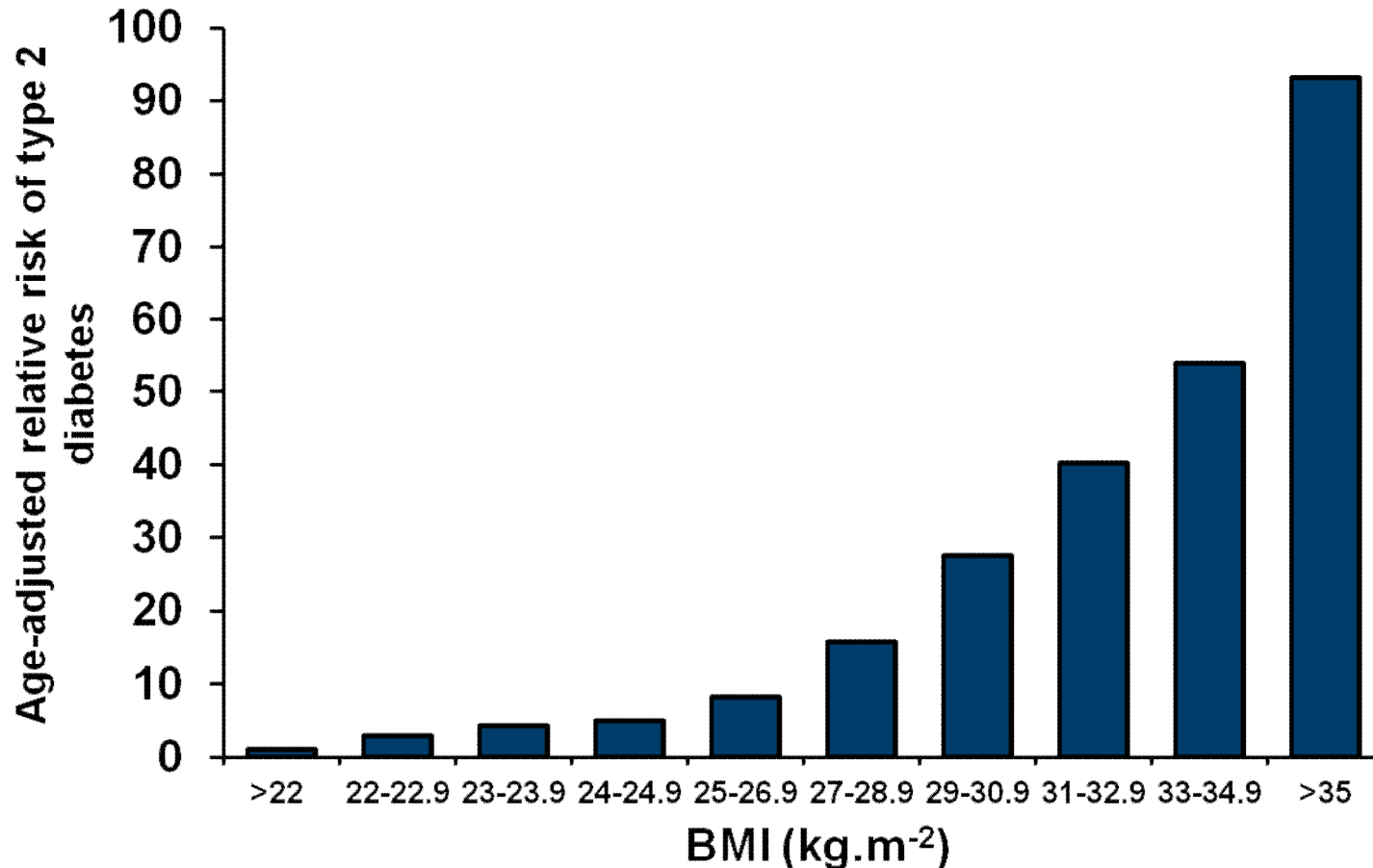
International Diabetes Federation

Diabetes prevalence in Northern Ireland

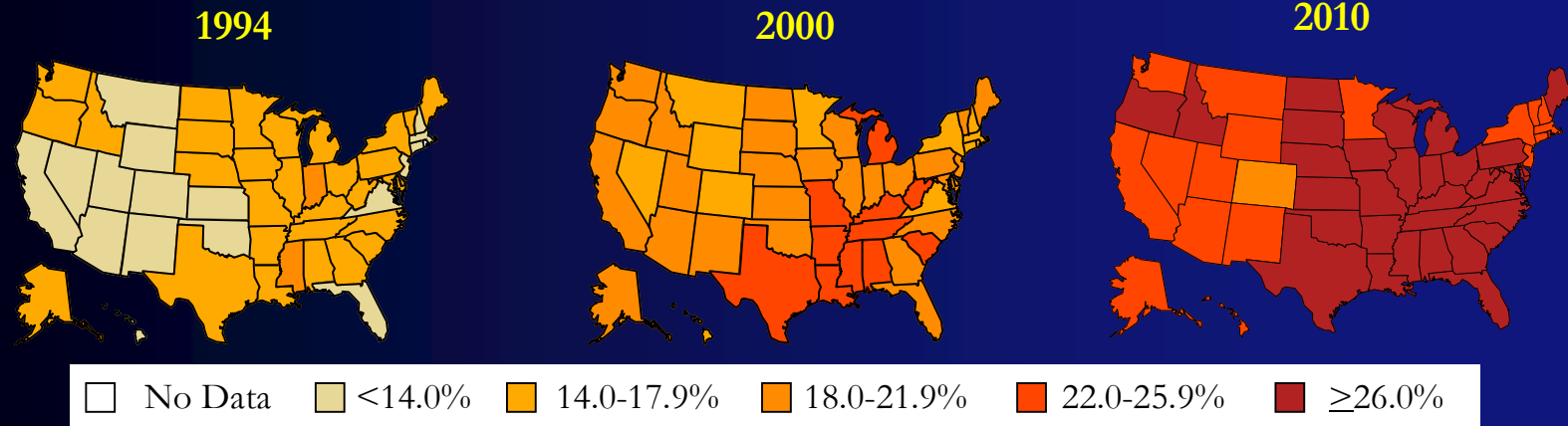Northern Ireland Health and Social Wellbeing Survey 2005/2006

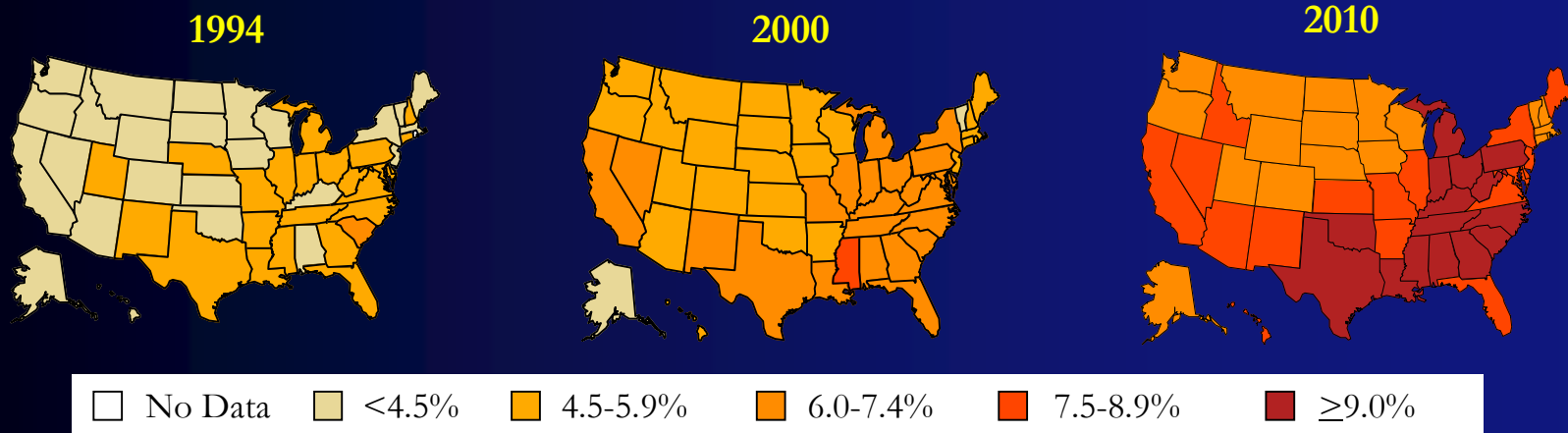# Obesity and type 2 diabetes: The Nurses Health Study

BMI >35 kg.m^{-2} associated with 93 times the risk of type 2 diabetes compared with BMI <22 kg.m^{-2}

Colditz et al (1995) Ann Intern Med, 122:481-486

Age-Adjusted Prevalence of Obesity and Diagnosed Diabetes Among U.S. Adults Aged 18 Years or older

Obesity (BMI ≥30 kg/m^2)

1994 **2000** **2010**

| | No Data | | <14.0% | | 14.0-17.9% | | 18.0-21.9% | | 22.0-25.9% | | ≥26.0% |

Diabetes

1994 **2000** **2010**

| | No Data | | <4.5% | | 4.5-5.9% | | 6.0-7.4% | | 7.5-8.9% | | ≥9.0% |

Epidemiology of physical activity, fitness & sedentary behaviour, and risk of diabetes

Global burden of physical inactivity
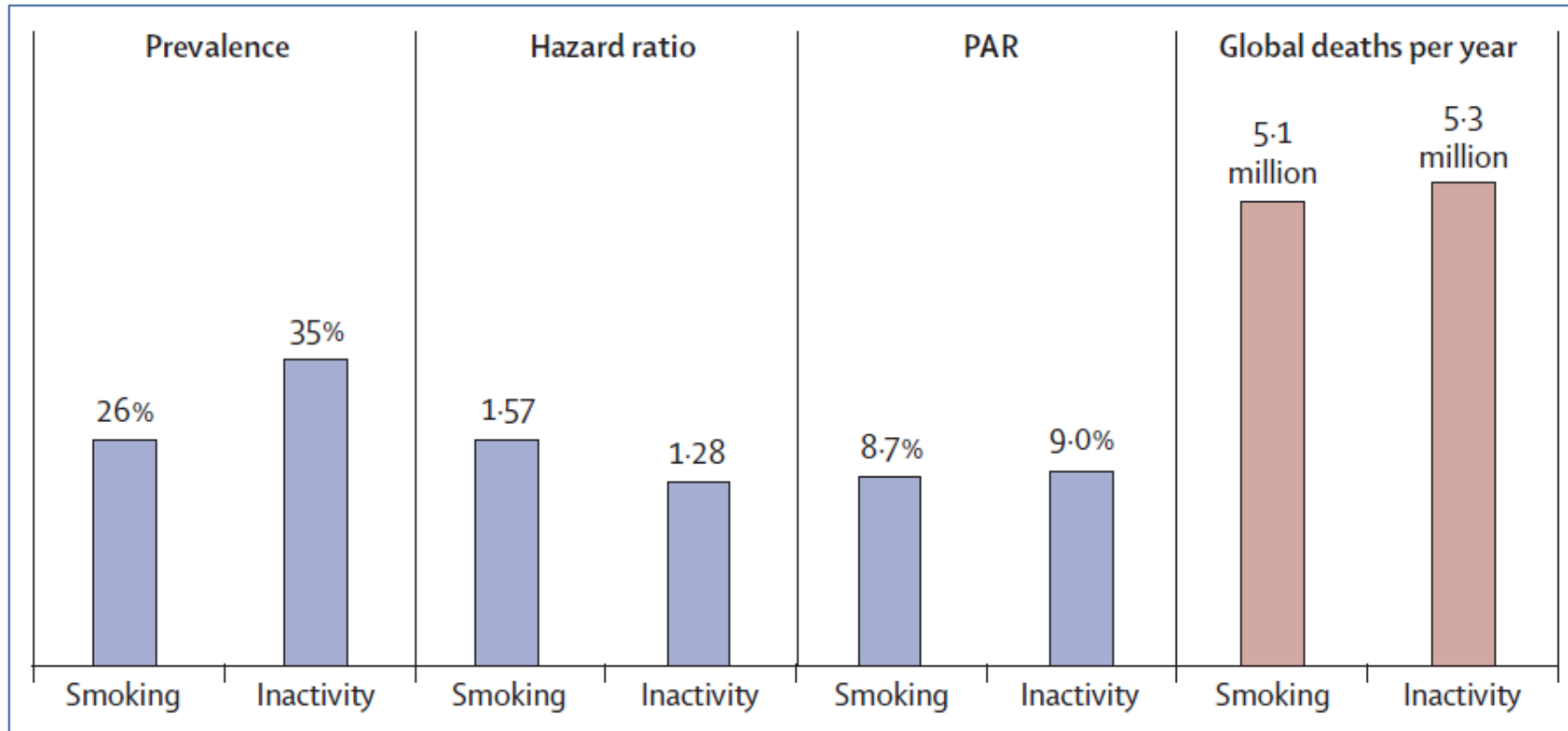
Figure: Comparison of global burden between smoking and physical inactivity

Prevalence of smoking, population attributable risk (PAR), and global deaths for smoking were obtained from WHO.[7] Hazard ratio for all-cause mortality of smoking was obtained from meta-analysis studies.[8,9] All inactivity data were obtained from Lee and colleagues.[5]

Wen and Wu (2012) The Lancet http://dx.doi.org/10.1016/S0140-6736(12)60954-4

Meta-analysis of effects of physical activity on type 2 diabetes risk

RR of type 2 diabetes with adjustment for BMI
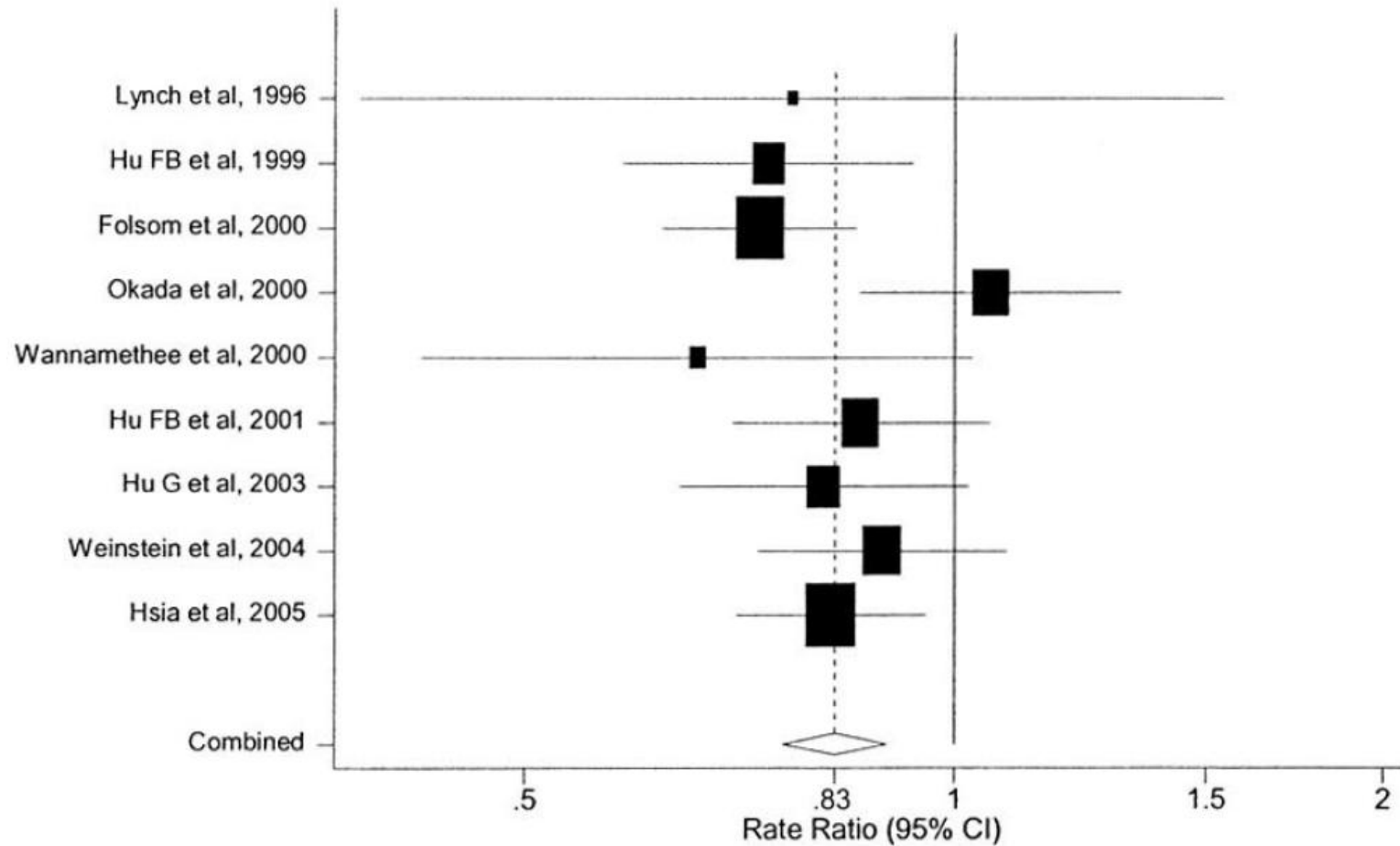
Jeon et al, 2007, Diabetes Care, 30:744-752

UK Physical Activity Guidelines

ADULTS (19–64 years)

1. Adults should aim to be active daily. Over a week, activity should add up to at least 150 minutes (2½ hours) of moderate intensity activity in bouts of 10 minutes or more – one way to approach this is to do 30 minutes on at least 5 days a week.

2. Alternatively, comparable benefits can be achieved through 75 minutes of vigorous intensity activity spread across the week or a combination of moderate and vigorous intensity activity.

3. Adults should also undertake physical activity to improve muscle strength on at least two days a week.

4. All adults should minimise the amount of time spent being sedentary (sitting) for extended periods.

(Department of Health, 2011)

Fitness, BMI and risk of type 2 diabetes: The Aerobics Center Longitudinal Study
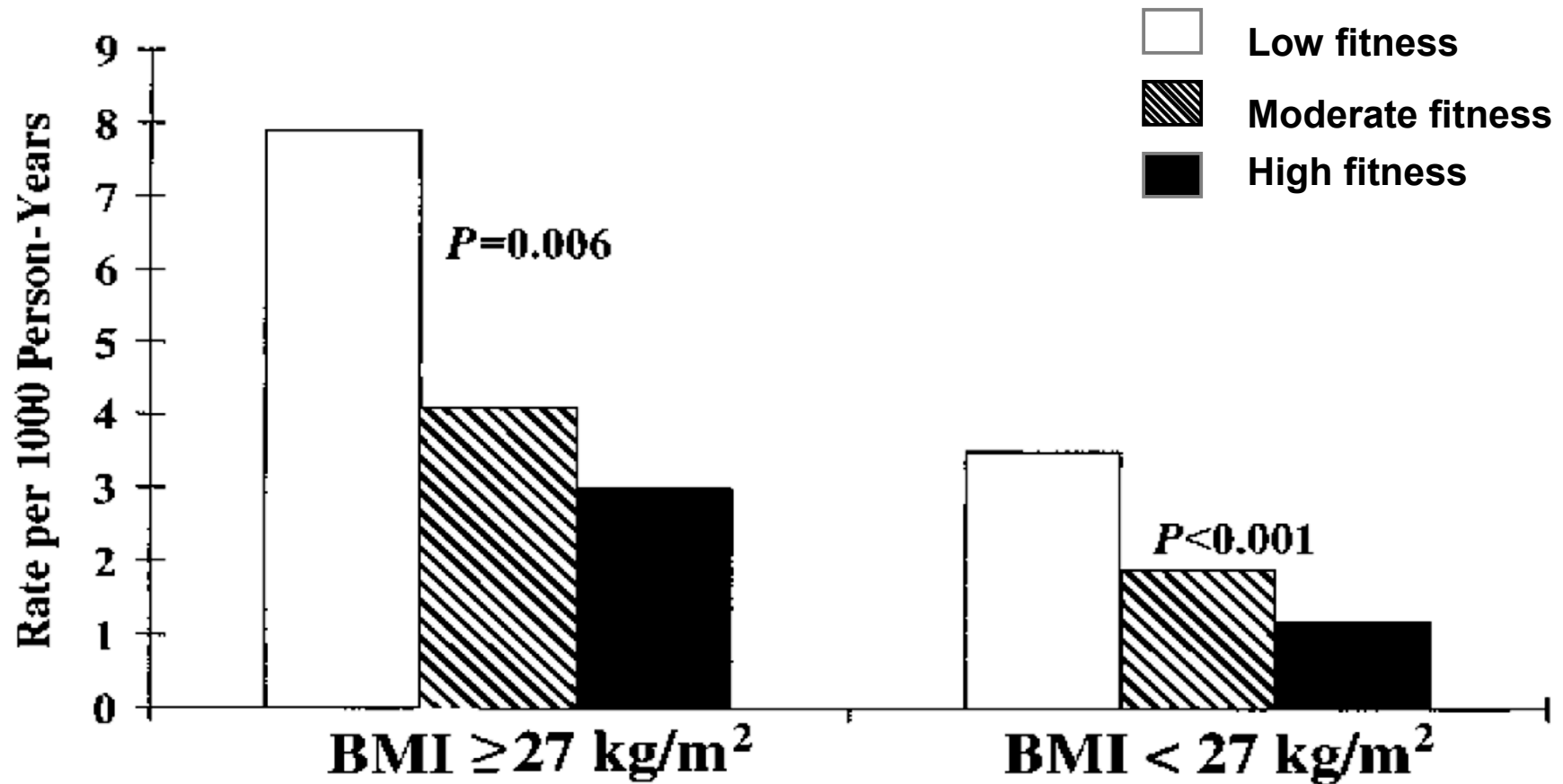
□ Low fitness

▨ Moderate fitness

■ High fitness

P=0.006

P<0.001

BMI ≥ 27 kg/m² BMI < 27 kg/m²

Rate per 1000 Person-Years

Wei et al (1999) Ann Intern Med, 130:89-96

Mail Online

Building the plane that builds economies.

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Sitting can be more dangerous than smoking, study shows

By DAILY MAIL REPORTER

Last updated at 11:20 PM on 9th June 2011

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Going to work could be more harmful than smoking, a new study shows.

That is if your job involves sitting around for long periods of time.

NEWS

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Sitting may be worse for your health than you thought

Physical inactivity increases risk of life-threatening conditions

Madeline Rossman

Sitting Too Long Raises Death Risk

Huffington Post | Amanda Chan | First Posted: 06/24/11 03:36 PM ET | Updated: 06/27/11 05:08 PM ET

React ▶ | Amazing | Inspiring | Funny | Scary | Hot | Crazy | Important | Weird |

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Like   You like Sitting Too Long Raises Death

| 332 | 180 | 55 | 3 |

f share   tweet   email   +1

Get up off your chair -- your life is at stake, a new study suggests.

Sitting more than six hours a day raises your risk of death, even if you work out, said the study, published in the *American Journal of Epidemiology*.

Even if they exercised, women who sat six or more hours a day were 37 percent more likely to die over a 13-year period than people who sat less than

---

06/15/2011 10:19 AM   ID: 89737

TV Watching Increases Risk of Dying Rather Young

Several recently conducted studies found that watching TV can actual increase the risk of health problems and of dying at an earlier age.

Two hours more in front of the TV on a typical day increase the risk o type 2 diabetes by 20 percent and the risk of developing a heart disea 15 percent up.

For every additonal 3 hours watching the telly, the risk of dying from increases 13 percent.
The average American spends 5 hours daily sitting in front of the tube

Meta-analysis of effects of sedentary time on diabetes risk

Wilmot et al, 2012, Diabetologia, 55:2895-2905
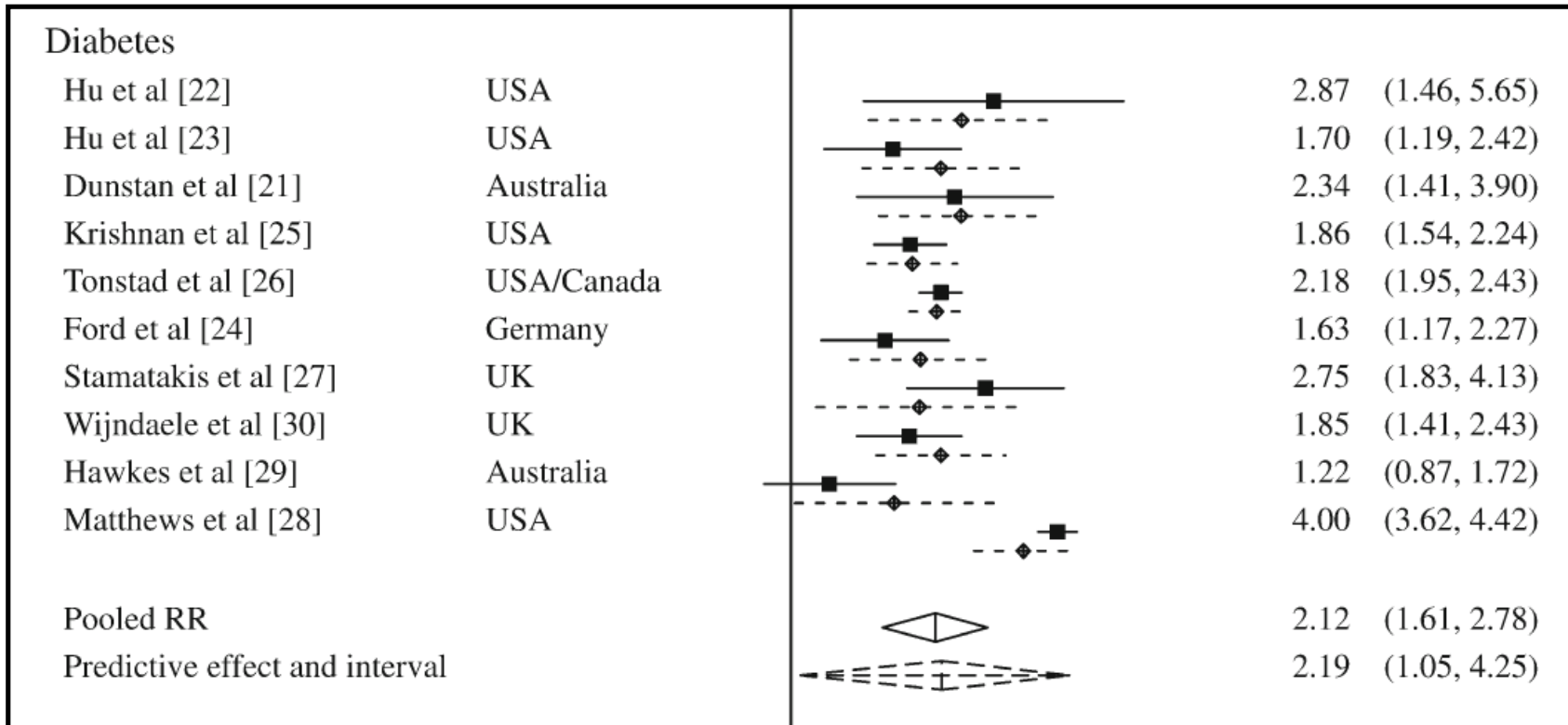
Sitting time and glycaemia in South Asians (n = 1228)

	Two-hour glucose concentration	
	Difference in glucose (mmol/L)	P
Age (per year)	0.032 (0.016–0.049)	<0.0005
Sex (men compared with women)	0.000 (−0.360 to 0.360)	0.999
Waist (per cm)	0.057 (0.040–0.074)	<0.0005
Sitting time (per h/day)	0.097 (0.036–0.158)	0.002
Walking time (per h/day)	−0.040 (−0.312 to 0.232)	0.774
Moderate activity time (per h/day)	−0.083 (−0.410 to 0.244)	0.620
Vigorous activity time (per h/day)	−0.819 (−1.672 to 0.034)	0.060

Data are means (95% CI).

Effect of each hour of sitting on glycaemia equivalent to 3 years in age or 2 cm in waist

Gill et al (2011) Diabetes Care:1214-1218

Lifestyle intervention trials for diabetes prevention

Long-term follow-up in US Diabetes Prevention Program
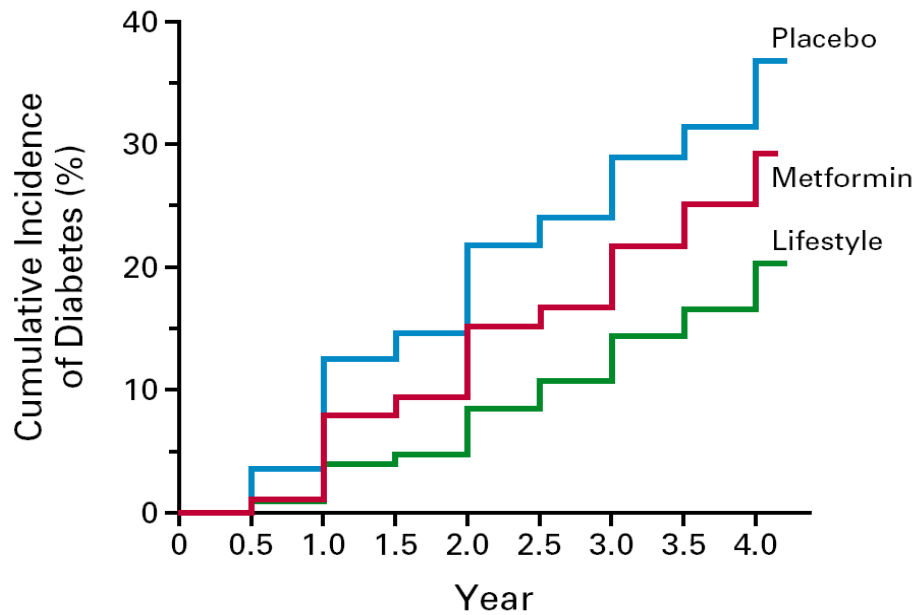
Knowler et al (2002) NEJM, 346:393-403
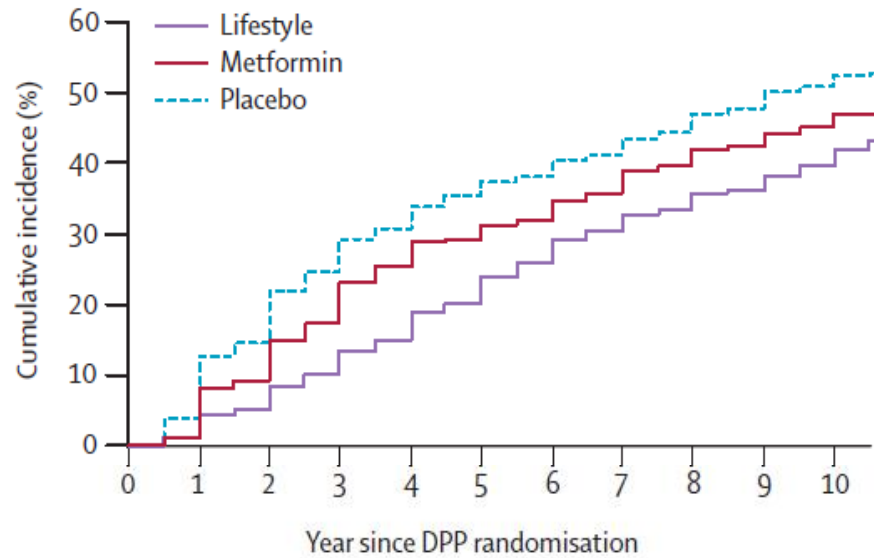
Knowler et al (2009) Lancet, 374:1677-86

Long-term effects of lifestyle intervention in IGT on diabetes-related microvascular complications: The Da Qing Study

Cumulative incidence of severe retinopathy
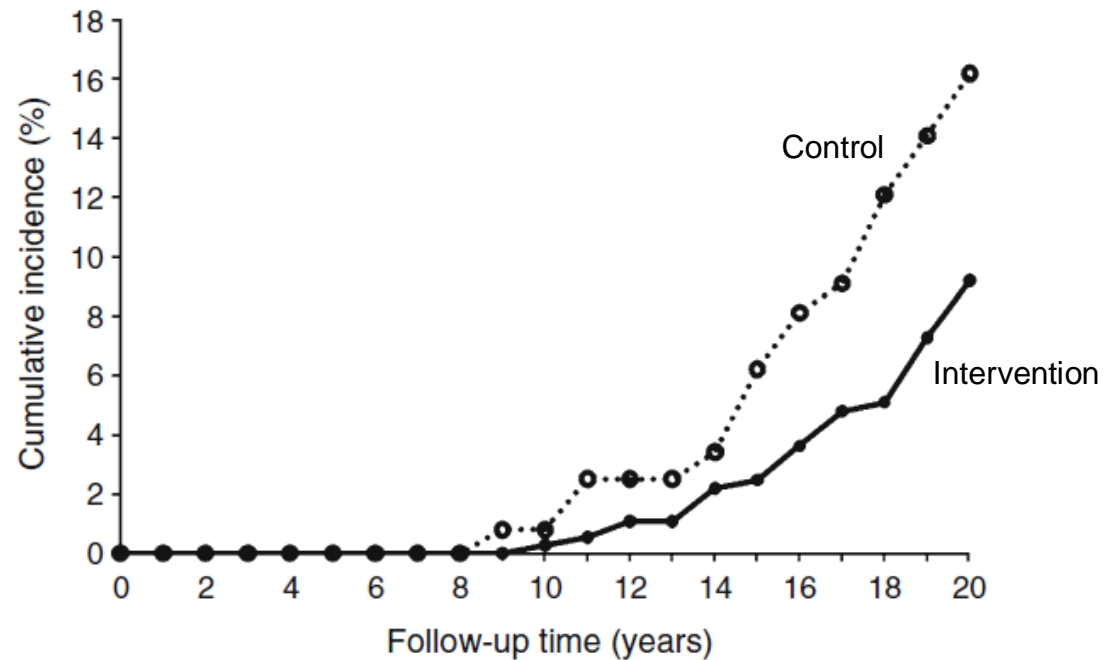
Gong et al (2011) Diabetologia, 54:300-307

Lifestyle intervention trials for diabetes treatment

Aerobic training, resistance training or both on glycaemic control in type 2 diabetes

Variable	Mean (SD) Value			Difference in Change from Baseline to 6 Months (95% CI)	P Value
	Baseline	3 mo	6 mo		
Hemoglobin A$_{1c}$ [patients], % [n]†					
Combined exercise group	7.46 (1.48) [64]	6.99 (1.56) [60]	6.56 (1.55) [58]	–	–
Aerobic training group	7.41 (1.50) [60]	7.00 (1.59) [58]	6.98 (1.50) [49]	–	–
Resistance training group	7.48 (1.47) [64]	7.35 (1.57) [62]	7.18 (1.52) [56]	–	–
Control group	7.44 (1.38) [63]	7.33 (1.49) [62]	7.51 (1.47) [59]	–	–
Intergroup comparisons					
Aerobic training vs. control	–	–	–	−0.51 (−0.87 to −0.14)	0.007
Resistance training vs. control	–	–	–	−0.38 (−0.72 to −0.22)	0.038
Combined exercise vs. aerobic training	–	–	–	−0.46 (−0.83 to −0.09)	0.014
Combined exercise vs. resistance training	–	–	–	−0.59 (−0.95 to −0.23)	0.001

˝ **Control group** (n = 63) . no exercise

˝ **Aerobic training group** (n = 60) . building to 45 mins cycling/treadmill exercise @ 75% max HR 3 x per week

˝ **Resistance training group** (n = 64) . 2-3 sets of 7 resistance exercises 3 x per week

˝ **Combined training group** (n = 64) . the full aerobic AND the full resistance intervention

Sigal et al (2007) Ann Intern Med, 147:357-369

ACSM/ADA recommendations for Physical activity in treatment of type 2 diabetes

- Persons with type 2 diabetes should undertake at least 150 min/week of moderate to vigorous aerobic exercise spread out during at least 3 days during the week, with no more than 2 consecutive days between bouts of aerobic activity.
- In addition to aerobic training, persons with type 2 diabetes should undertake moderate to vigorous resistance training at least 2–3 days/week.
- Supervised and combined aerobic and resistance training may confer additional health benefits, although milder forms of PA (such as yoga) have shown mixed results. Persons with type 2 diabetes are encouraged to increase their total daily unstructured PA. Flexibility training may be included but should not be undertaken in place of other recommended types of PA.

Colberg et al (2010) Diabetes Care, 33:e147-e167

Long-term effects of lifestyle intervention on weight & CVD risk in type 2 diabetes: the Look AHEAD trial

˝ 5145 adults aged 45-76 years with type 2 diabetes randomised to Intensive Lifestyle Intervention (n = 2570) or Diabetes Support and Education (n = 2575).

˝ **Intensive Lifestyle Intervention (ILI)**
  ˝ dietary goal to induce 7% weight loss and 175 minutes moderate intensity physical activity per week
  ˝ Supported by group/individual support sessions weekly for first 6 months; 3 x per months from 6-12 months; once per month (plus 1 telephone/email contact per month) for years 2-4.
  ˝ Behaviour change strategies taught (self-monitoring, goal setting, problem solving), weigh-ins at each session,

˝ **Diabetes Support and Education (DSE)**
  ˝ 3 group sessions per year focused on diet, physical activity or social support.
  ˝ No behaviour change strategies taught, no weigh ins

Wing et al (2010) Arch Intern Med, 170:1566-1575

Long-term effects of lifestyle intervention on weight & CVD risk in type 2 diabetes: the Look AHEAD trial

Table 1. Mean Changes in Weight, Fitness, and CVD Risk Factors in ILI and DSE Groups and the Difference Between Groups Averaged Across 4 Years

Measure	Groups, Mean Change (95% CI)		Between-Group Mean Difference (95% CI)	P Value of Difference[a]
	DSE	ILI		
Weight, % initial weight	−0.88 (−1.12 to −0.64)	−6.15 (−6.39 to −5.91)	−5.27 (−5.61 to −4.93)	<.001
Fitness, % METS	1.96 (1.07 to 2.85)	12.74 (11.87 to 13.62)	10.78 (9.53 to 12.03)	<.001
HbA$_{1c}$ level[b]	−0.09 (−0.13 to −0.06)	−0.36 (−0.40 to −0.33)	−0.27 (−0.32 to −0.22)	<.001
SBP, mm Hg[b]	−2.97 (−3.44 to −2.49)	−5.33 (−5.80 to −4.86)	−2.36 (−3.03 to −1.70)	<.001
DBP, mm Hg[b]	−2.48 (−2.73 to −2.24)	−2.92 (−3.16 to −2.68)	−0.43 (−0.77 to −0.10)	.01
HDL-C level, mg/dL[b]	1.97 (1.73 to 2.22)	3.67 (3.43 to 3.91)	1.70 (1.35 to 2.04)	<.001
Triglycerides level, mg/dL[b]	−19.75 (−22.11 to −17.39)	−25.56 (−27.91 to −23.21)	−5.81 (−9.14 to −2.48)	<.001
LDL-C level, mg/dL				
Without adjustment for medication use	−12.84 (−13.67 to −12.00)	−11.27 (−12.10 to −10.44)	1.57 (0.39 to 2.74)	.009
Adjusted for medication use	−9.22 (−10.04 to −8.39)	−8.75 (−9.56 to −7.94)	0.47 (−0.67 to 1.60)	.42

Wing et al (2010) Arch Intern Med, 170:1566-1575

Long-term effects of lifestyle intervention on weight & CVD risk in type 2 diabetes: the Look AHEAD trial

Table 2. Proportion of DSE and ILI Participants Who Initiated or Maintained Use of Medication for Diabetes, Hypertension, or Lowering Lipid Levels

| | Use of Medication at Follow-up by Group | | | | | |
| | No Use at Baseline | | | Continued Use From Baseline | | |
	DSE	ILI	P Value	DSE	ILI	P Value
Diabetes medication						
No. at baseline[a]	348	354		2208	2202	
Follow-up year, %						
1	33.1	10.4	<.001	97.5	89.4	<.001
2	46.3	17.4	<.001	96.3	88.2	<.001
3	58.6	27.3	<.001	95.4	89.2	<.001
4	66.8	41.8	<.001	96.0	90.6	<.001
Insulin						
No. at baseline[a]	2167	2190		408	380	
Follow-up year, %						
1	3.7	1.7	<.001	91.6	80.6	<.001
2	6.7	3.1	<.001	86.4	76.1	<.001
3	8.9	4.3	<.001	86.3	77.7	.004
4	11.5	6.9	<.001	88.0	77.4	<.001

Table 2. Proportion of DSE and ILI Participants Who Initiated or Maintained Use of Medication for Diabetes, Hypertension, or Lowering Lipid Levels

| | Use of Medication at Follow-up by Group | | | | | |
| | No Use at Baseline | | | Continued Use From Baseline | | |
	DSE	ILI	P Value	DSE	ILI	P Value
Hypertension medication						
No. at baseline[a]	684	661		1872	1895	
Follow-up year, %						
1	21.9	16.4	.01	89.9	81.3	<.001
2	31.9	24.7	.005	90.4	81.0	<.001
3	40.3	33.3	.01	91.2	82.9	<.001
4	47.2	43.0	.15	92.7	85.0	<.001
Lipid-lowering medication						
No. at baseline[a]	1313	1310		1243	1246	
Follow-up year, %						
1	25.3	17.6	<.001	92.3	89.6	.03
2	39.8	29.0	<.001	90.7	89.1	.22
3	47.4	38.5	<.001	88.6	90.0	.26
4	53.2	47.2	.004	90.9	90.4	.72

Wing et al (2010) Arch Intern Med, 170:1566-1575

Long-term effects of lifestyle intervention on weight & CVD risk in type 2 diabetes: the Look AHEAD trial

U.S. Department of Health and Human Services

NIH News

National Institutes of Health

For Immediate Release
Friday, October 19, 2012
Contact:
Amy Reiter
301-496-3583

Weight loss does not lower heart disease risk from type 2 diabetes Intervention stopped early in NIH-funded study of weight loss in overweight and obese adults with type 2 diabetes after finding no harm, but no cardiovascular benefits

An intensive diet and exercise program resulting in weight loss does not reduce cardiovascular events such as heart attack and stroke in people with longstanding type 2 diabetes, according to a study supported by the National Institutes of Health.

Summary (part 1)

- Epidemiological evidence shows strong associations between low physical activity, low fitness and high sedentary time and risk of diabetes.

- RCTs indicate that lifestyle intervention is effective over the long-term of preventing diabetes and diabetes complications

- Lifestyle intervention is effective at improving glycaemic control, weight loss and reducing medication use, reducing sleep apnoea and improving mobility in type 2 diabetes

- Effects of lifestyle intervention is effective at reducing CVD events in highly-treated patients with type 2 diabetes not established

Should we intervene earlier for diabetes prevention?

And if so, who should we target for early intervention?
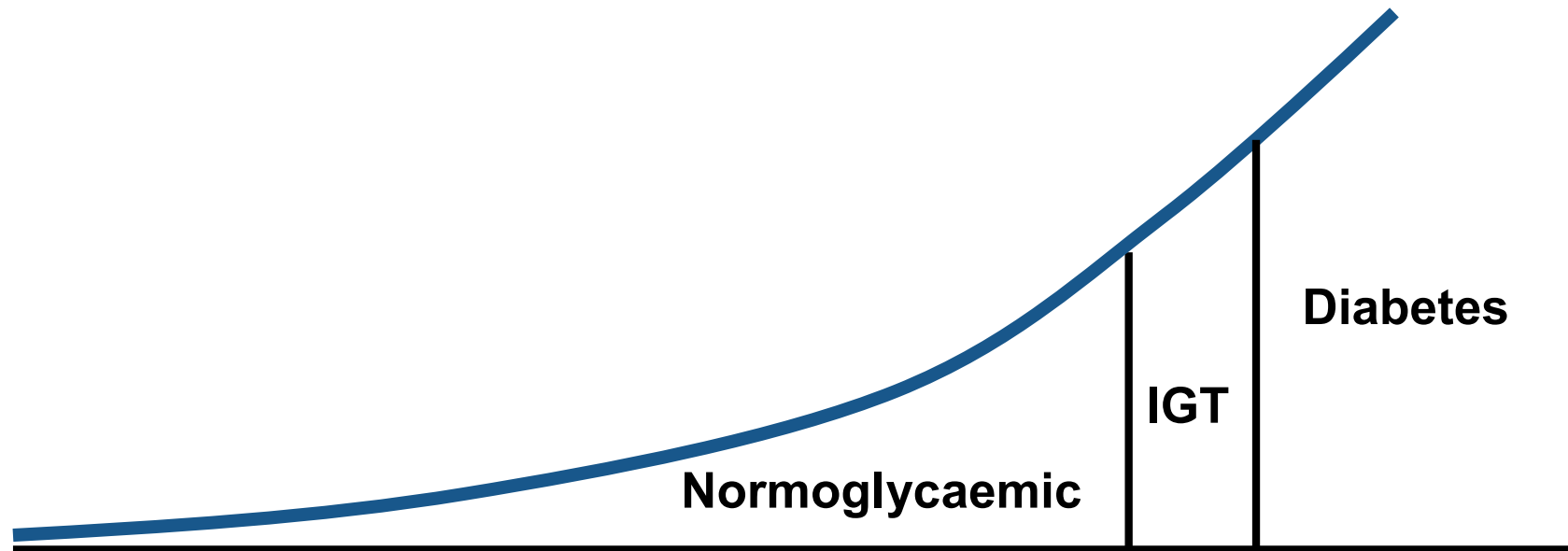
The diabetes risk continuum

Normoglycaemic

IGT

Diabetes

The diabetes risk continuum

~10% per year

Diabetes

IGT

Normoglycaemic

The diabetes risk continuum

Lifestyle intervention reduces conversion to diabetes by ~30-60%.

~10% per year

Diabetes

IGT

Normoglycaemic

The diabetes risk continuum

Lifestyle intervention reduces conversion to diabetes by ~30-60%.

~10% per year

Diabetes

IGT

Normoglycaemic
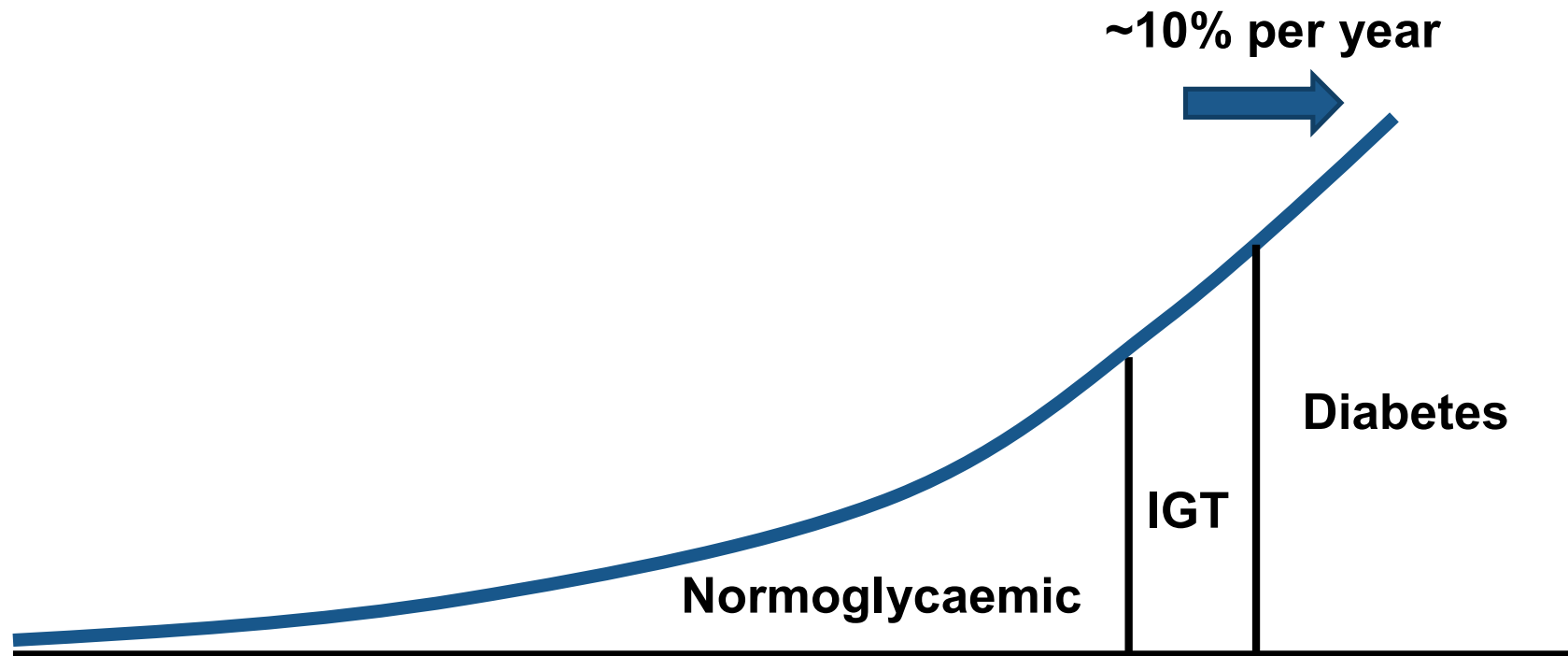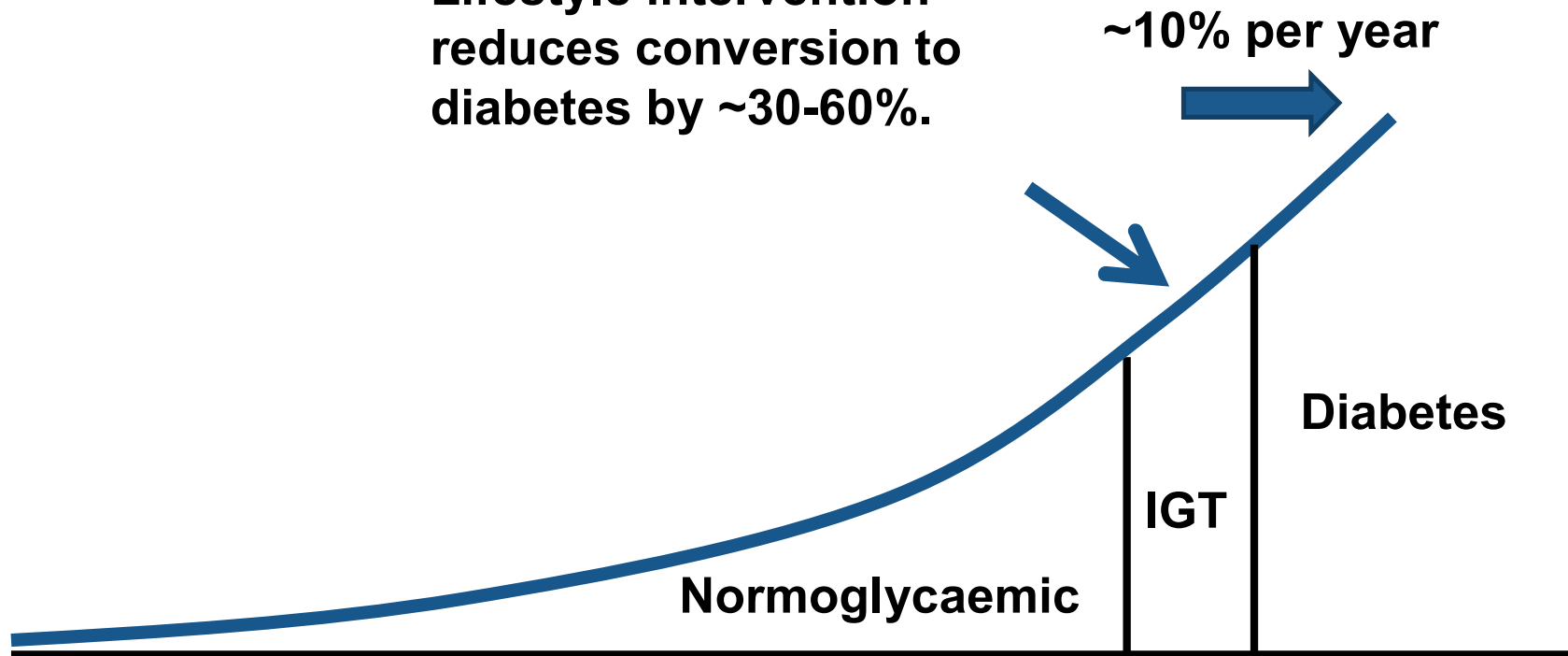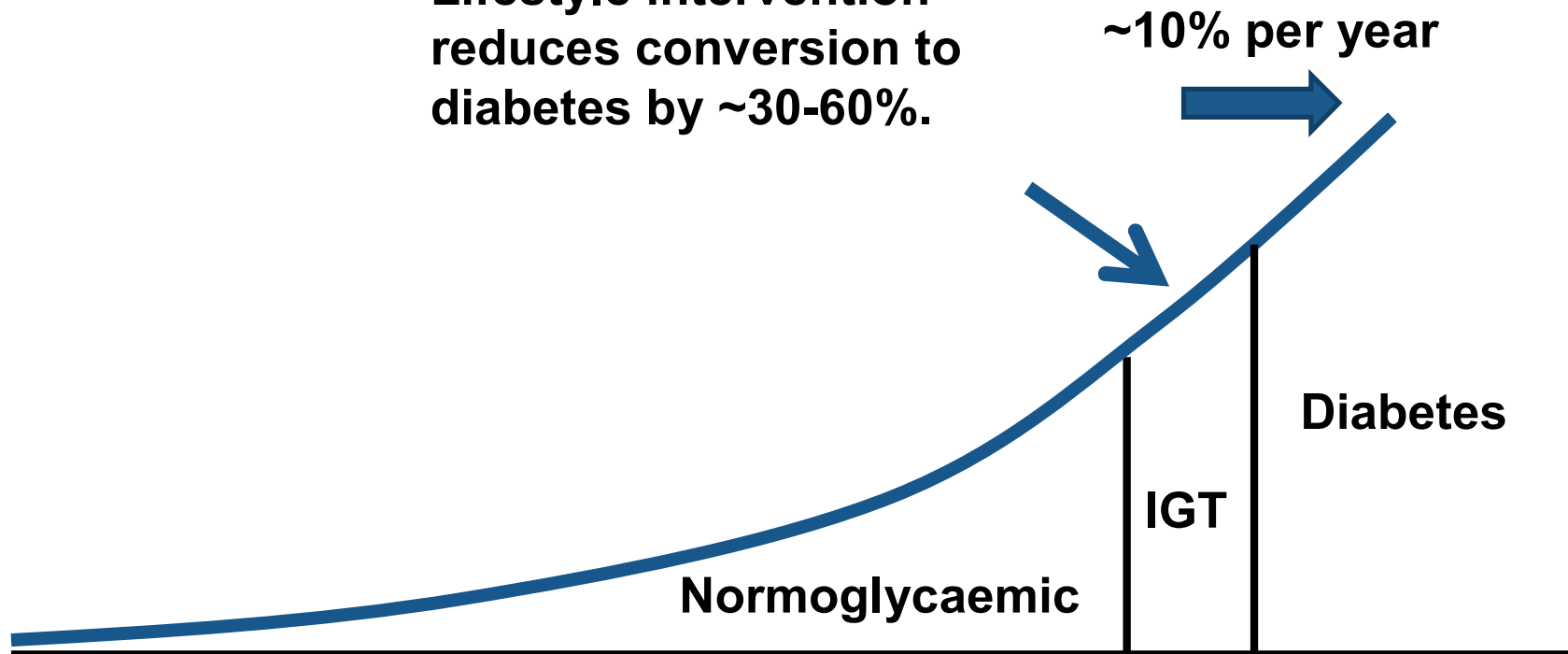
BUT – even with lifestyle intervention many with IGT still develop diabetes. Should we aim to intervene earlier?

Ethnicity, environment and diabetes
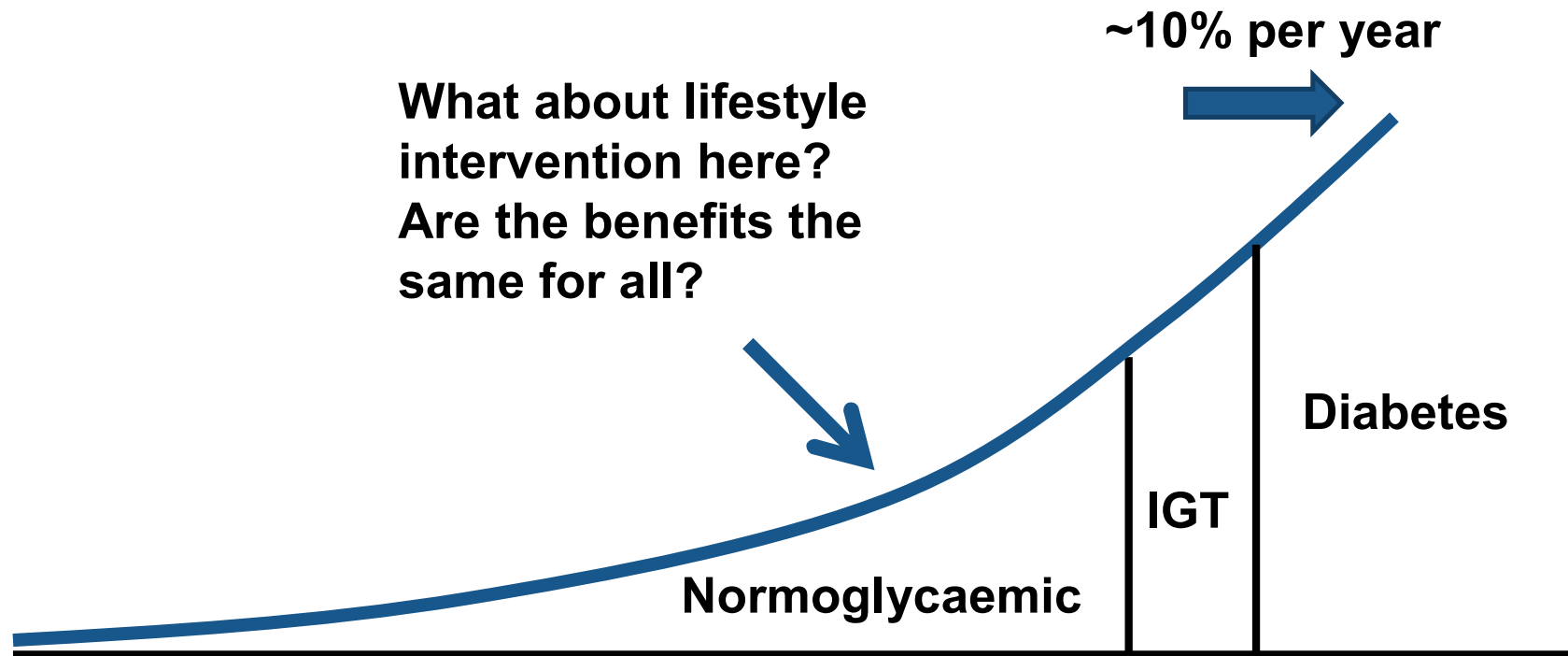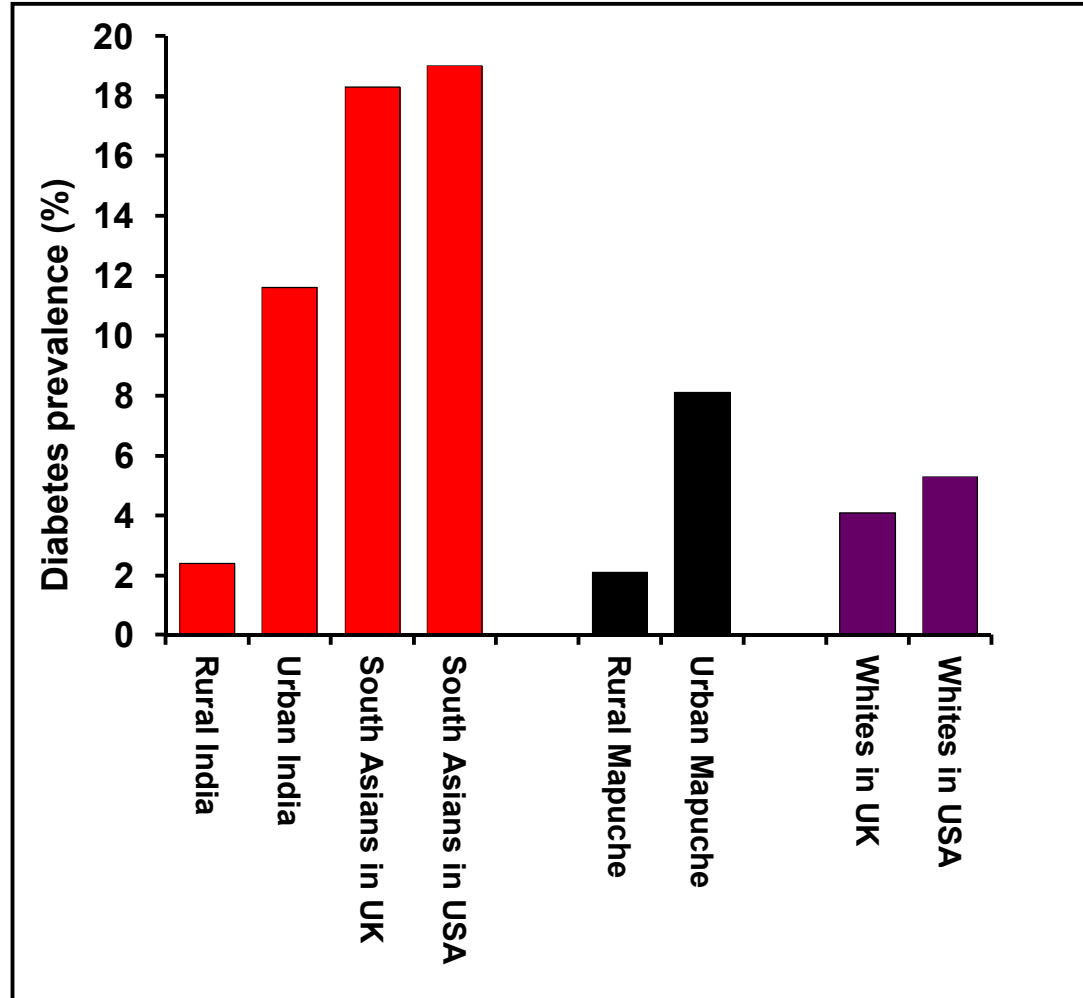
Hall et al (2008) Future Lipidol 3: 411-424; Carrasco et al (2004) Chilean Med J. 132: 1189-1197.

The diabetes risk continuum
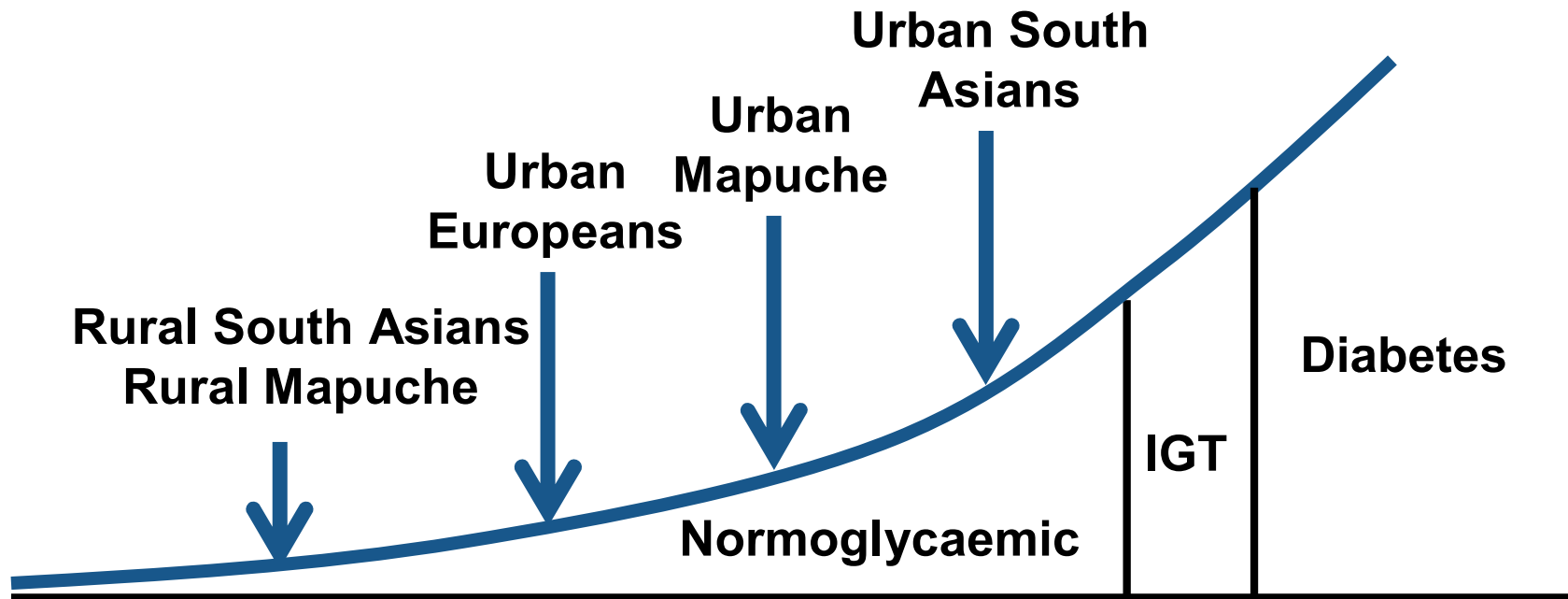
Ethnicity in Chile

Distribution of Chilean Population, Census 2002.

■ No aboriginal ■ Aboriginal

Aboriginal
4.6%

No aboriginal
95.4%

Total population: ~16 million

Total Aboriginal Population: 730,000

Mapuche Populations: >600,000

Effects of physical activity and sedentary behaviour on insulin resistance in European and Mapuche Chilean men
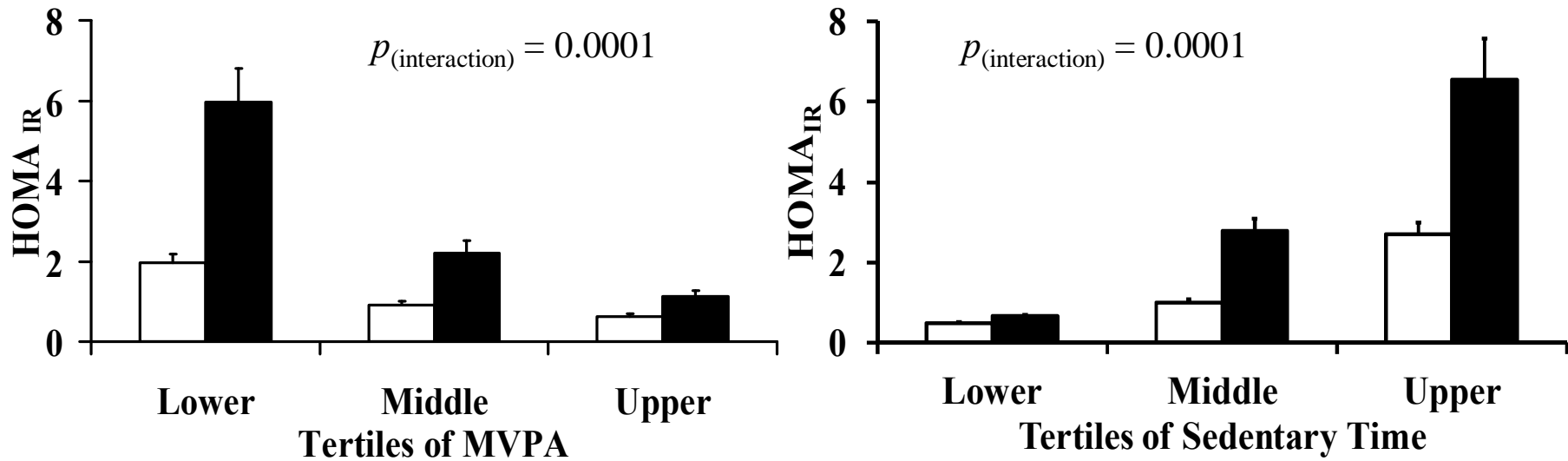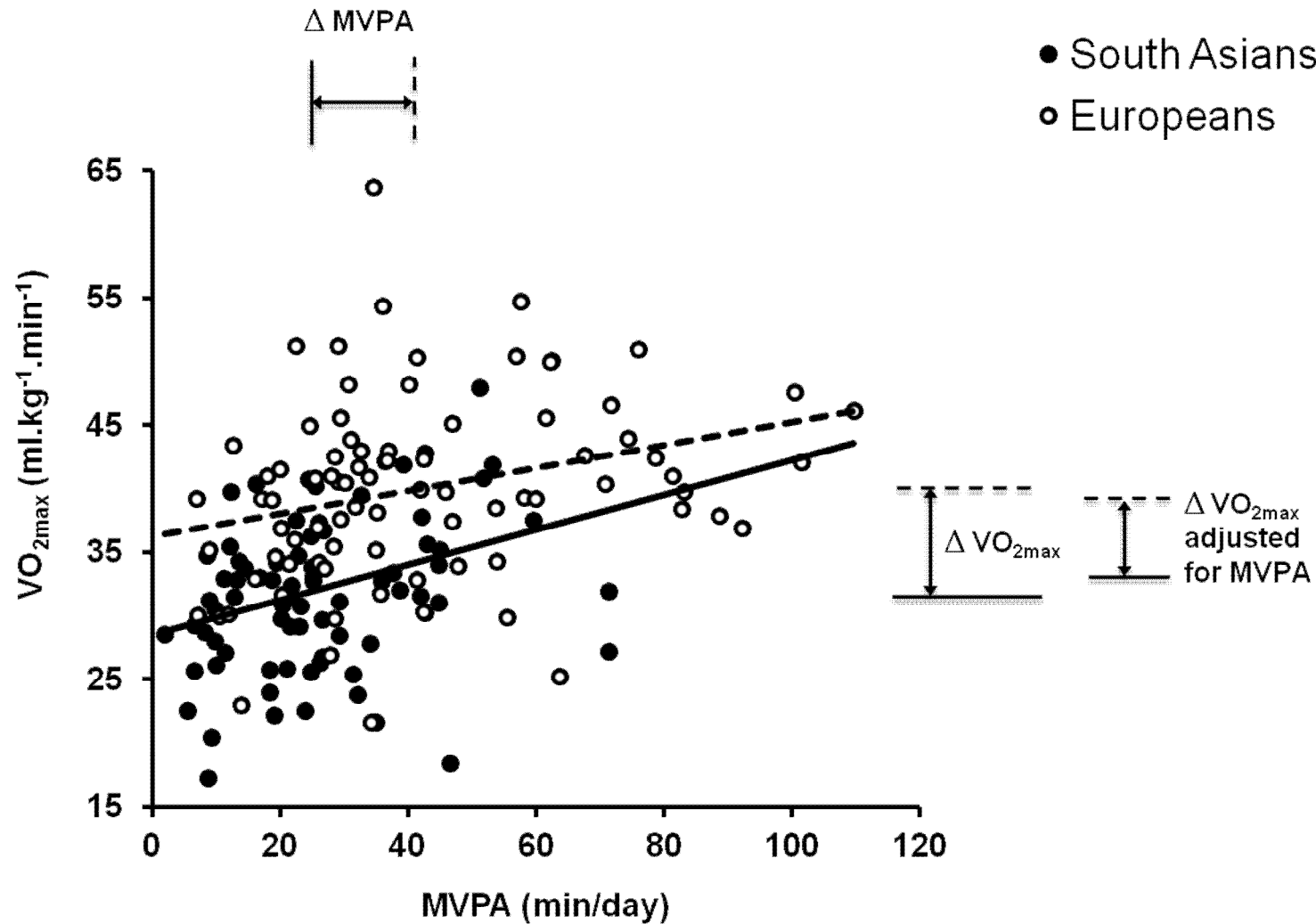
Celis-Morales et al (2011) PLoS ONE 6:e24690

Ghouri et al (under review)
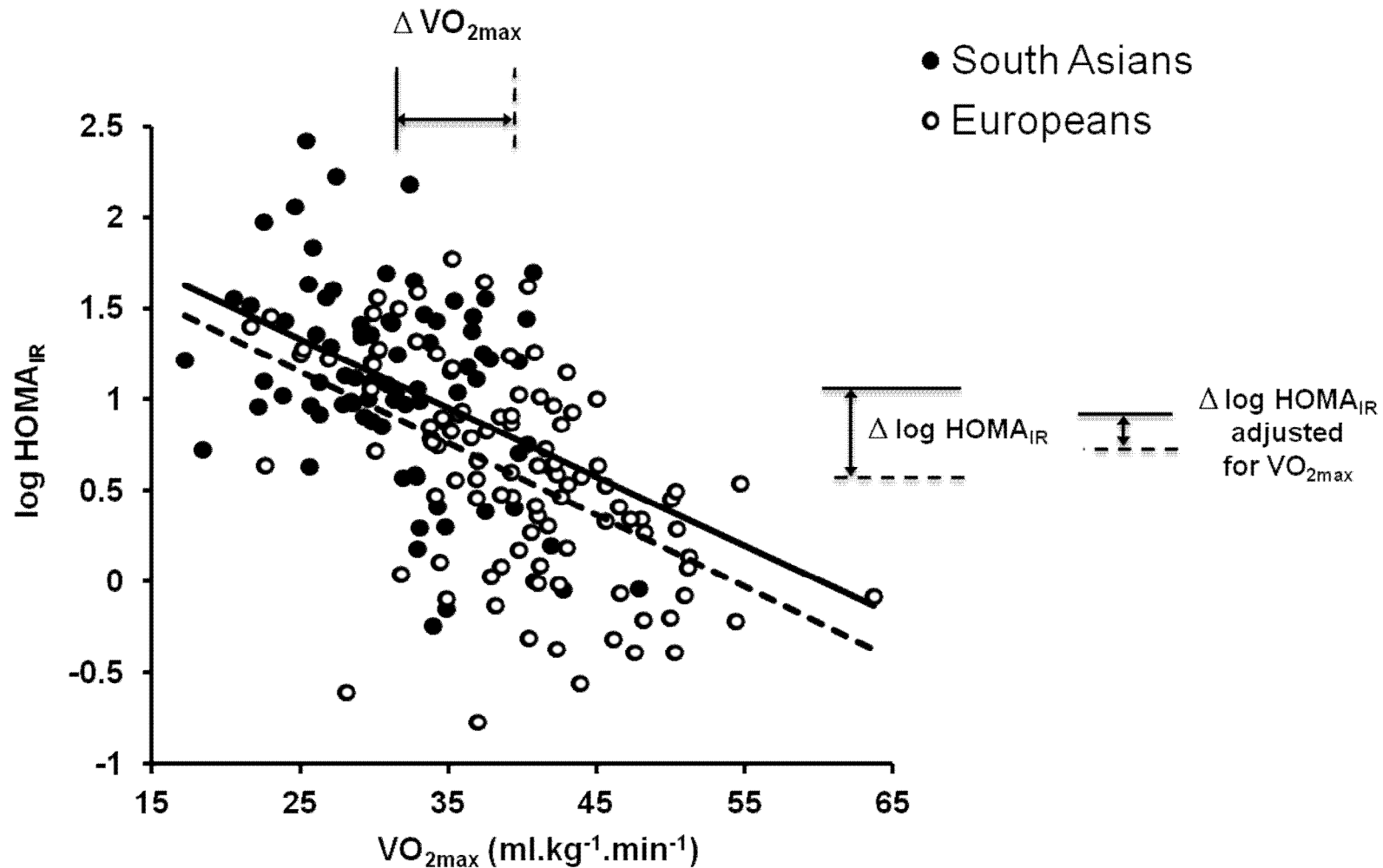
Ghouri et al (under review)

VO$_{2max}$, physical activity and insulin resistance in South Asians

- Low VO$_{2max}$ explains over two-thirds of South Asiansqgreater insulin resistance

- This is not explained by lower levels of physical activity

- South Asians need to undertake higher amounts of physical activity for similar VO$_{2max}$ (and HOMA$_{IR}$)

Fat oxidation during submaximal exercise in South Asian and European men

P for ethnicity = 0.003
(0.033 fully adjusted)

P for ethnicity = 0.001
(0.014 fully adjusted)

Hall et al (2010) PLoS ONE: 5(12): e14197
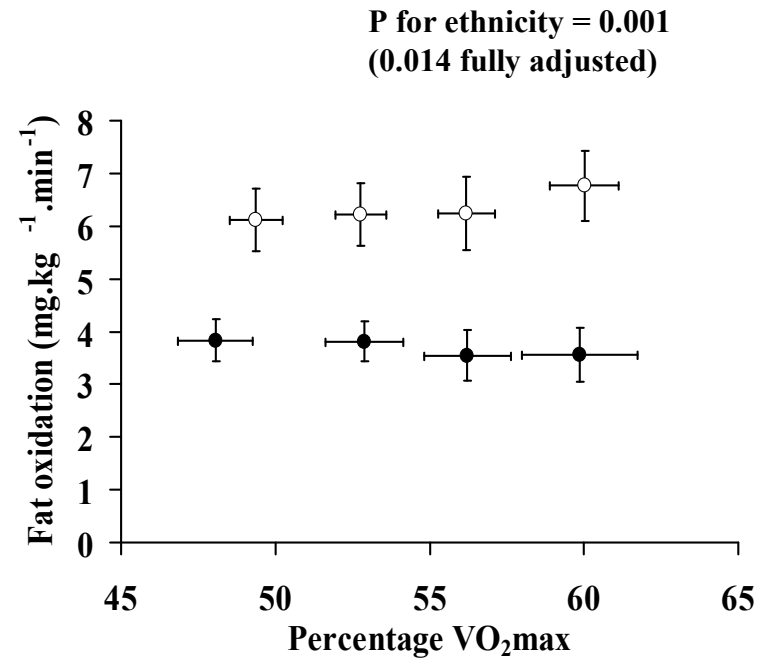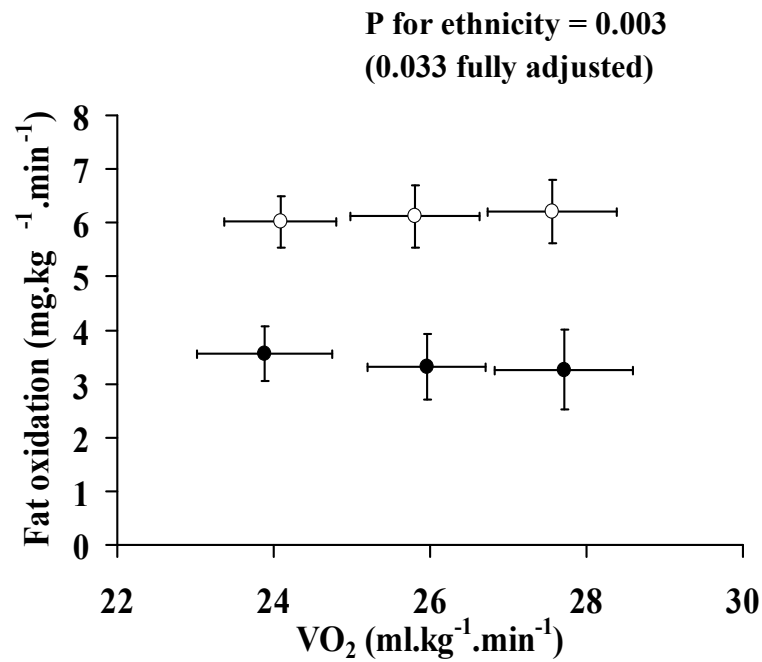
Substrate utilisation during exercise and insulin sensitivity in South Asian and European men
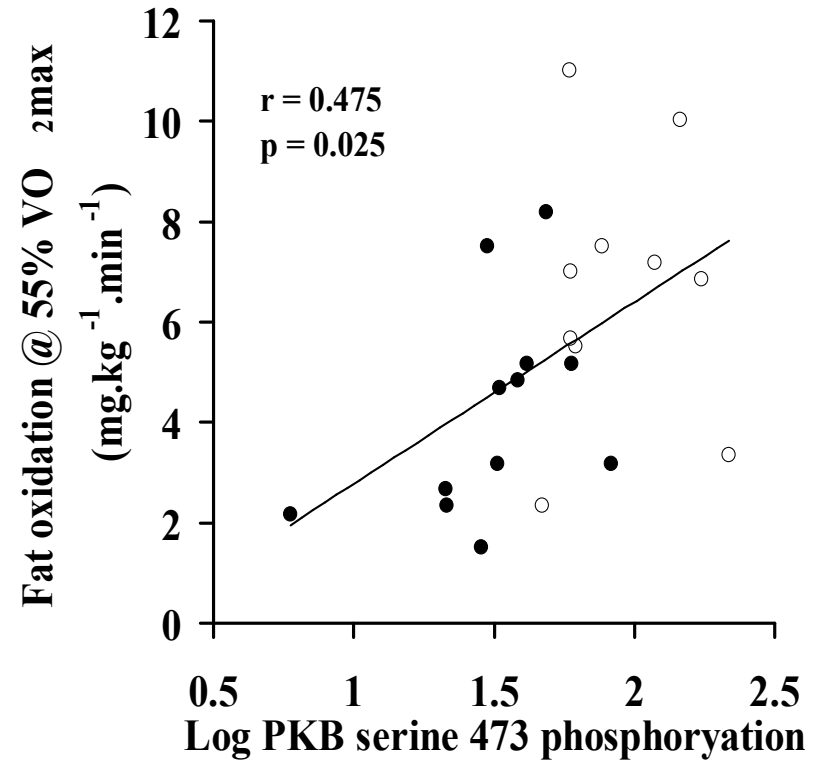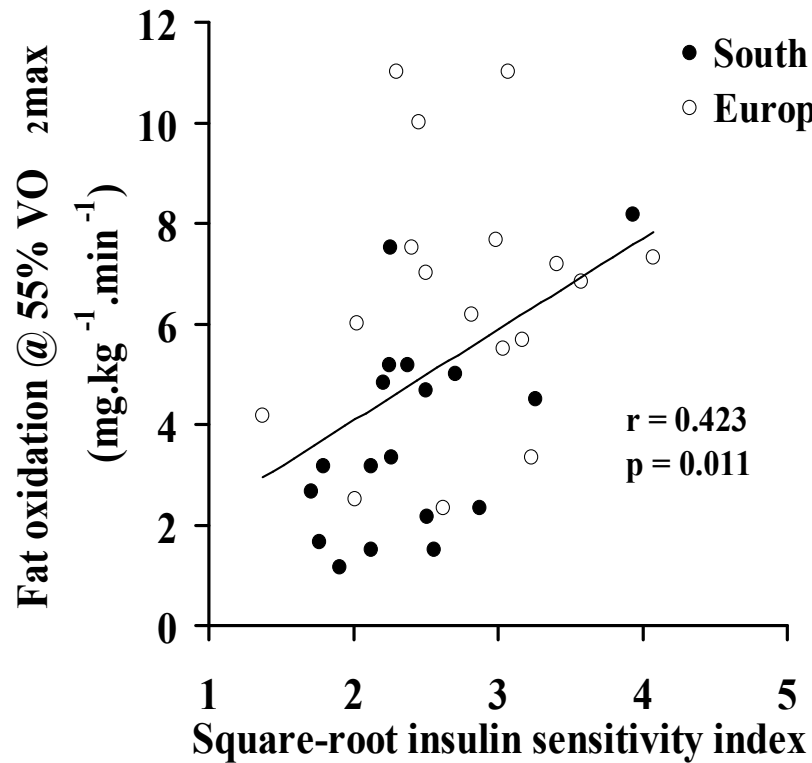
Hall et al (2010) PLoS ONE: 5(12): e14197
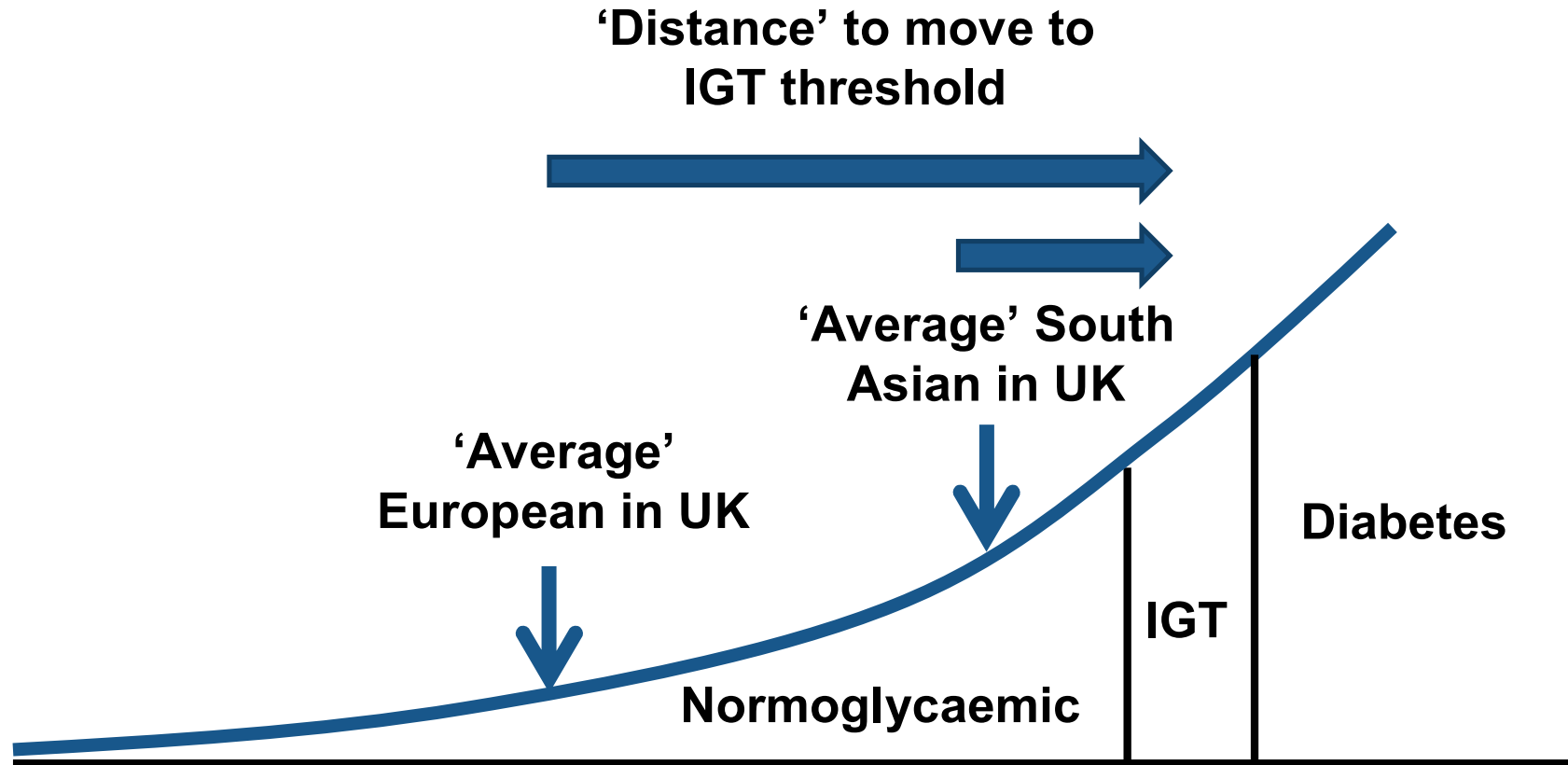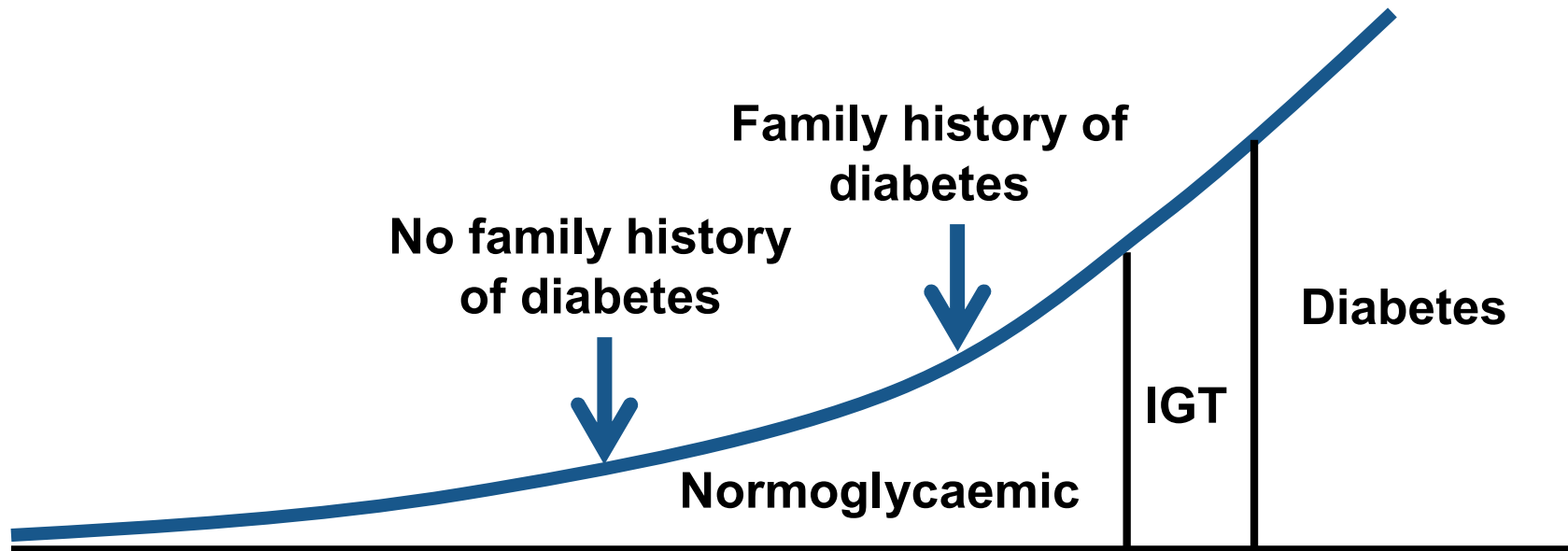
The diabetes risk continuum

Change in insulin sensitivity following a 7-week exercise intervention in women with and without a family history of diabetes
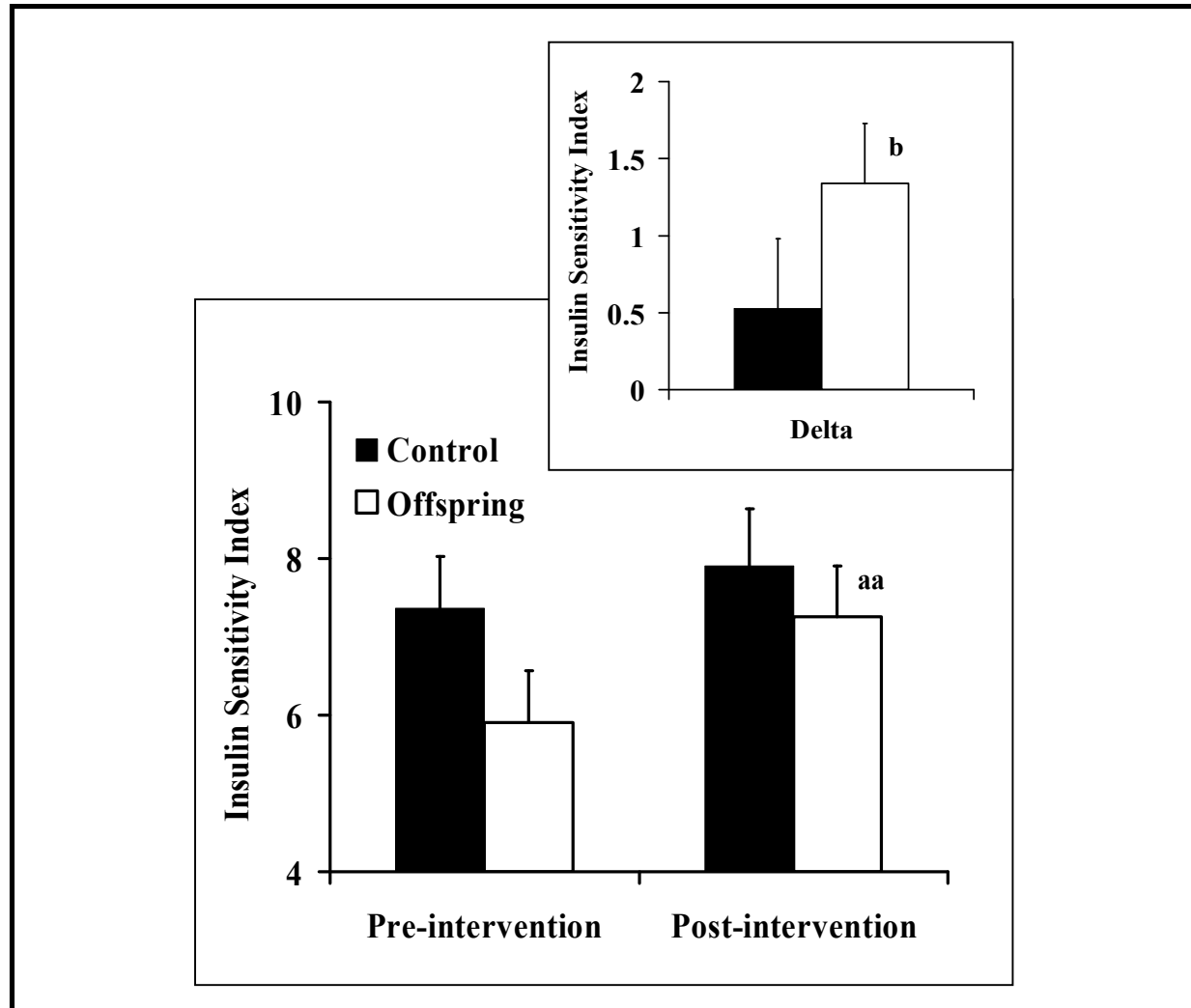
Barwell et al (2008) Diabetologia 51:1912-9
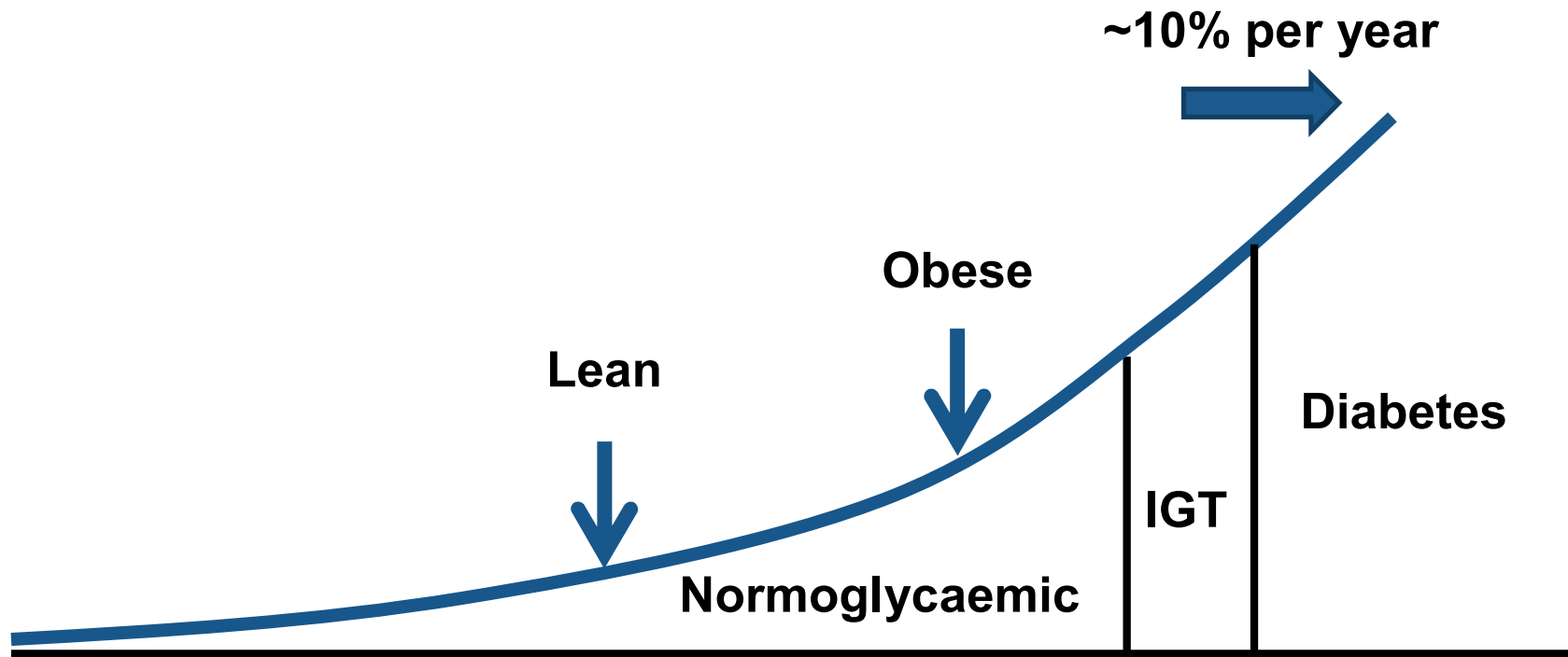
Moderate exercise and insulin responses in lean and obese men

Gill et al (2004) J Am Coll Cardiol, 44:2375-82

Summary (part 2)
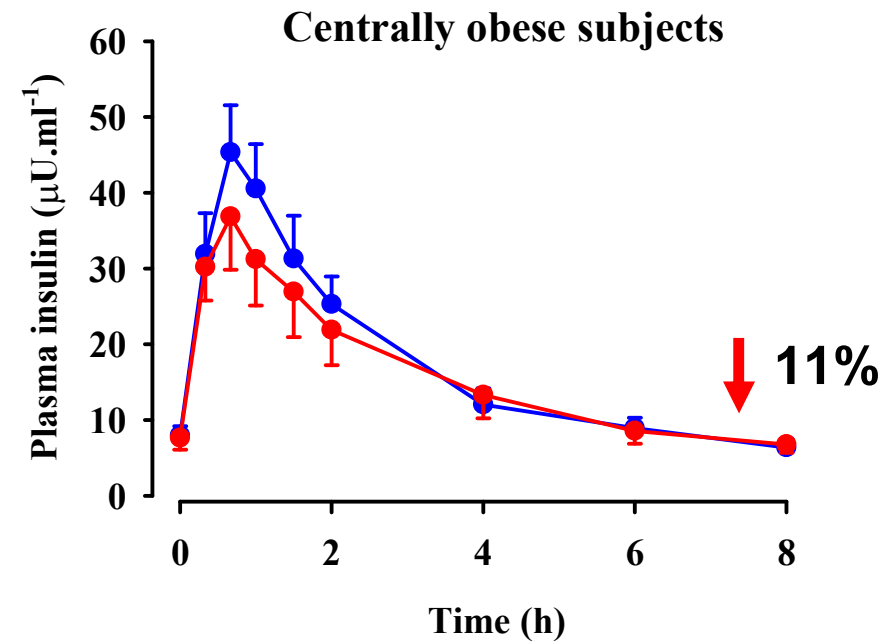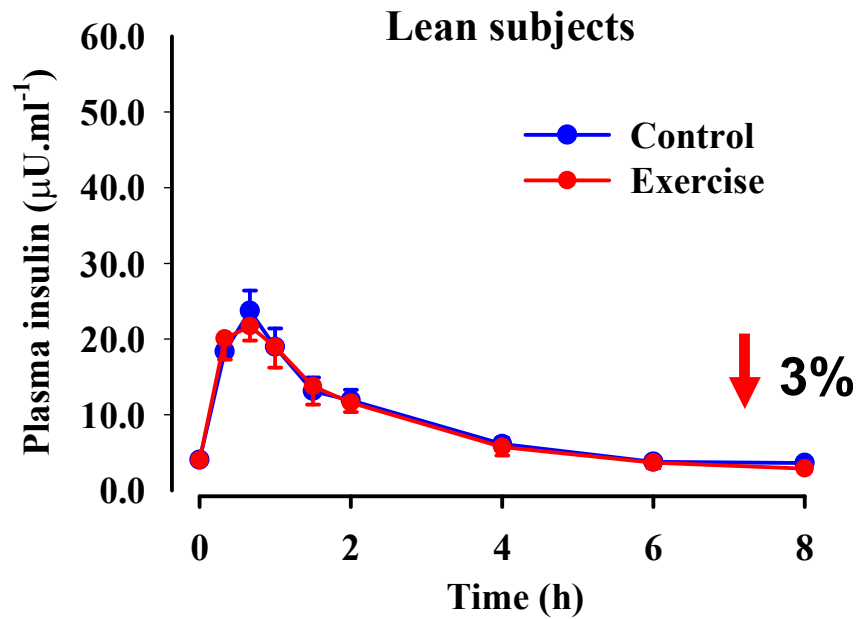
˝ Lifestyle intervention is effective at preventing diabetes in individuals with IGT

˝ But even with lifestyle intervention many with IGT will still develop diabetes.

˝ Within the normoglycaemic general population, there is a wide range of diabetes risk

˝ In groups at increased diabetes risk (e.g. diabetes family history, obese, South Asian, Mapuche), the benefits of increased physical activity appear particularly large

How much physical activity do people need to do?

Modified from Gill and Cooper (2008) Sports Med, 38: 807-824
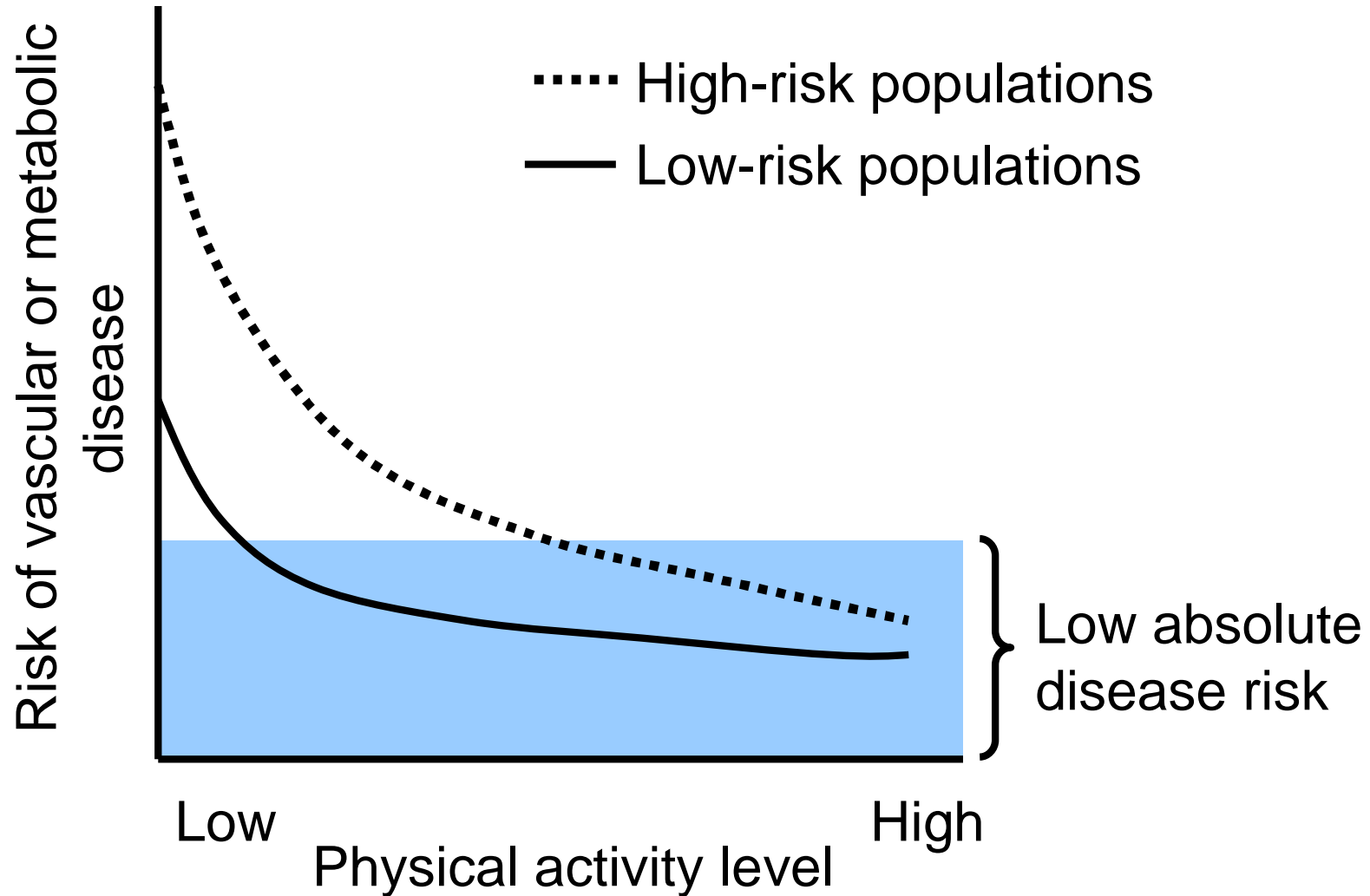
Should we be targeting these high-risk groups for diabetes prevention while they are still normoglycaemic?

Acknowledgements