Exercise and Diabetes

Georgia Diabetes Symposium for Health Professionals

November 12, 2016

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Assistant Professor of Medicine

Division of Endocrinology, Metabolism & Lipids

Emory University School of Medicine and the Atlanta VAMC

GEORGIA DIABETES SYMPOSIUM

FOR HEALTH PROFESSIONALS

Saturday, November 12, 2016

8:30am-5:00pm

Atlanta Marriott Marquis

265 Peachtree Center Ave NE,

Atlanta, GA 30303

Disclosures to Participants

Requirements for Successful Completion:

For successful completion, participants are required to be in attendance in the full activity, complete and submit the program evaluation at the conclusion of the educational event.

Conflicts Of Interest and Financial Relationships Disclosures

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Disclosures to Participants

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Activity-Type : Knowledge-based

This continuing nursing education activity was approved by The American Association of Diabetes Educators, an accredited approver by the American Nurses Credentialing Center's Commission on Accreditation. This program **2016-054** is awarded **6.0** contact hours of continuing education credit.

The AADE is also accredited by the California Board of Registered Nursing (CEP#10977).

The American Association of Diabetes Educators is accredited by the Accreditation Council for Pharmacy Education as a provider of continuing pharmacy education. This program provides **6.0** contact hours **(.60 CEU's)** of continuing education credit.

ACPE Universal Activity Number: 0069-0000-16-255-L01-P; 0069-0000-16-256-L01-P; 0069-0000-16-257-L01-P; 0069-0000-16-258-L01-P; 0069-0000-16-259-L01-P; 0069-0000-16-260-L01-P; 0069-0000-16-261-L01-P; 0069-0000-16-263-L01-P; 0069-0000-16-264-L01-P; 0069-0000-16-265-L01-P

Effective Date: November 12, 2016 to November 12, 2017

Sponsored by The Diabetes Association of Atlanta, a designated provider of continuing education contact hours (CECH) in health education by the National Commission for Health Education Credentialing, Inc. This program is designated for Certified Health Education Specialists (CHES) and/or Master Certified Health Education Specialists (MCHES) to receive up to **6** total Category I continue education contact hours.

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Objectives

- Explain the effects of exercise on blood sugar
- Discuss benefits of exercise in patients with diabetes
- Analyze treatment considerations when exercising with diabetes

Diabetes and Exercise

- Format: understand basics of diabetes and exercise, and introduce/review concepts to support new ADA Position Statement (2016)
- Background and Metabolism
- Benefits and Harms
- Treatment Considerations
- Review ADA Positon Statements

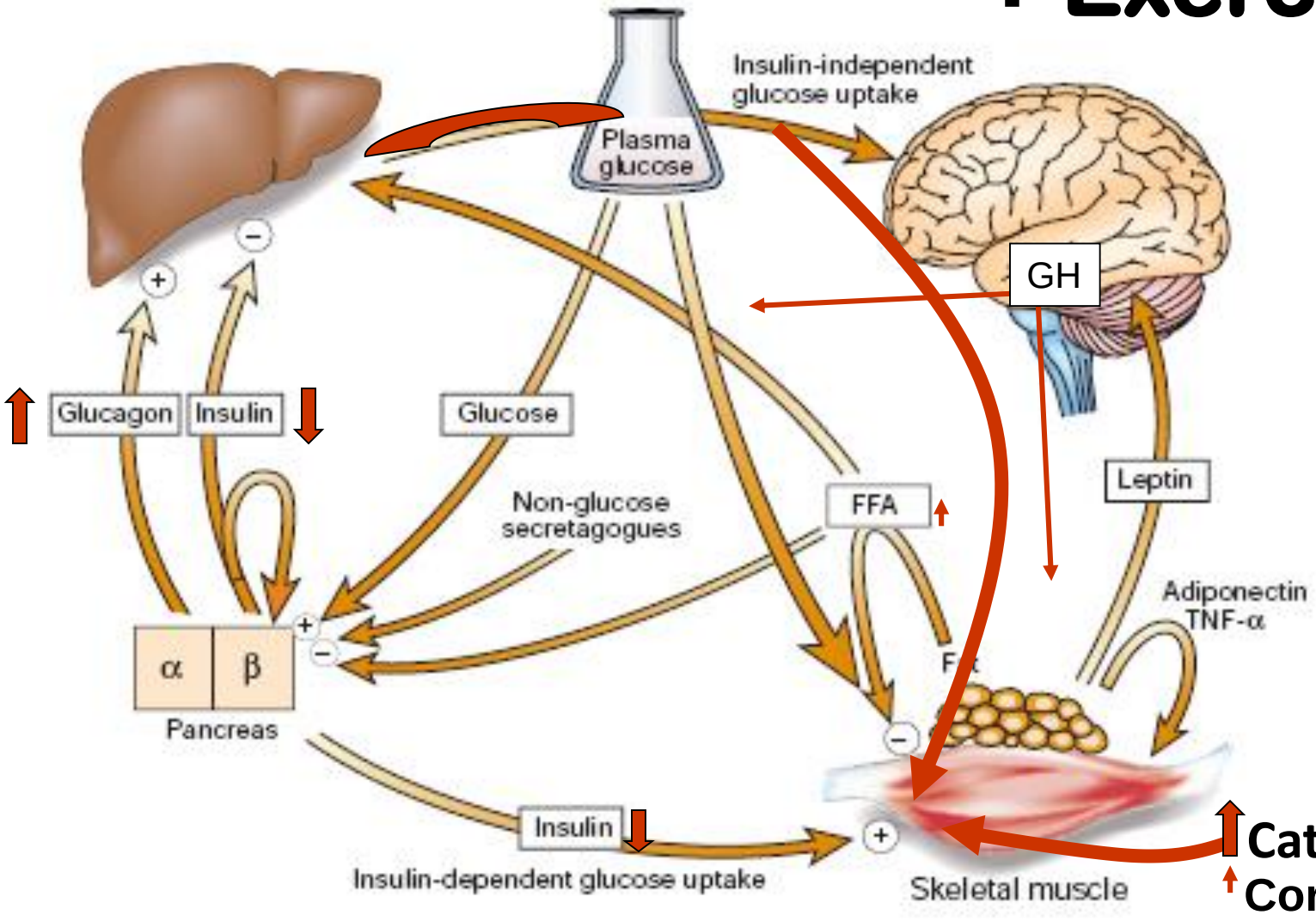
How does exercise affect blood sugar?

Exercise, Carbohydrate Metabolism, and Diabetes

What is reliably known?

- Hormones change to favor substrate availability
- Glucose and ATP stores used first during exercise
  - Intracellular glucose and glycogen
- Muscle glucose uptake increases
  - Blood glucose may decrease
- Hepatic glucose production increases
- Training adaptation

Whole body glucose metabolism + Exercise



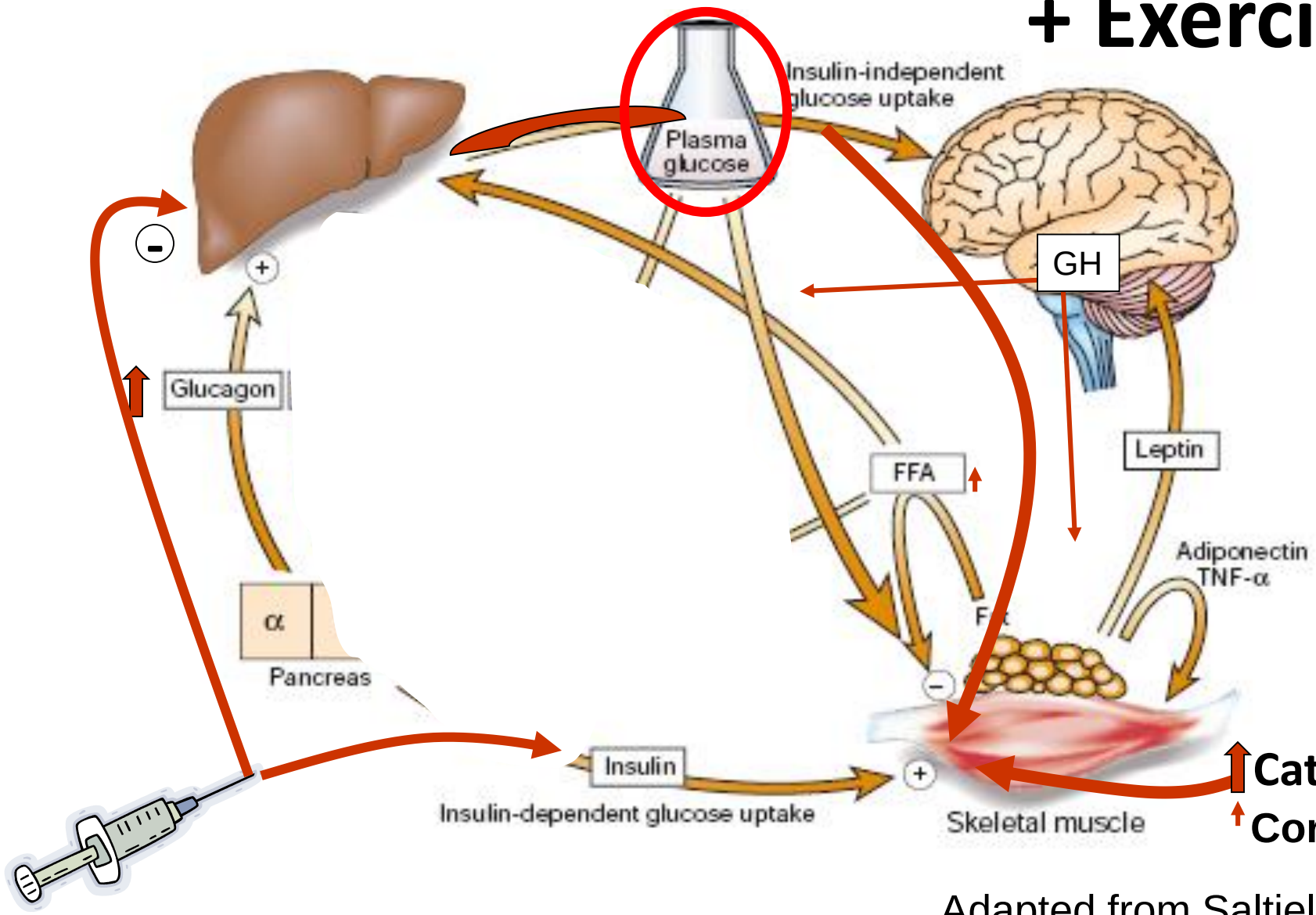
Adapted from Saltiel & Kahn. Nature, 2001

Hormonal changes during brief exercise

- Decrease Insulin
- Increase Catecholamines
- Increase Growth Hormone
- Increase Glucocorticoids
- Mild increase glucagon
- Slight increase in fatty acids
- Together lead to decline in BG
  - Compensate with carbohydrate ingestion or endogenous glucose production

Whole body glucose metabolism: Type 1 Diabetes

+ Exercise



Adapted from Saltiel & Kahn. Nature, 2001

The Decline in Blood Glucose Levels Is Less With Intermittent High-Intensity Compared With Moderate Exercise in Individu

KYM J. GUELFI, BSC(HON
TIMOTHY W. JONES, MD
PAUL A. FOURNIER, PHD

Brief example from recent data demonstrating hormonal responses to exercise are consistent/similar with diabetes

OBJECTIVE — To co
intensity exercise (IHE) a

RESEARCH DESIGN
betes were tested on two s
was performed. MOD co
involved a combination
performed every 2 min t

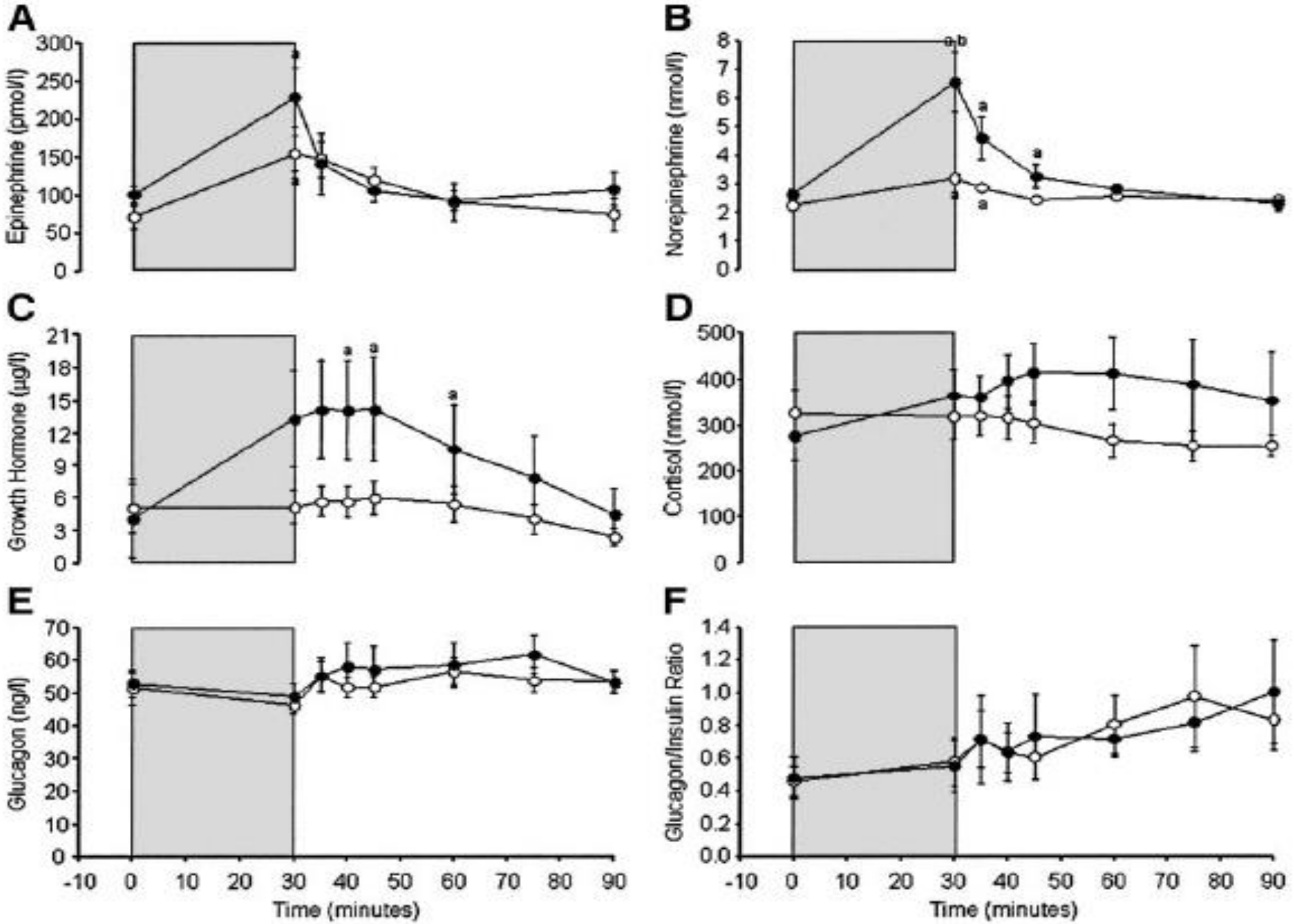
RESULTS — Both exe
the decline was greater
mmol/l; $P < 0.05$), desp
0.05). During 60 min of r
with MOD ($P < 0.05$). F
while they continued to d
with IHE was associated with elevated levels of lactate, catecholamines, and growth hormone during early recovery from exercise ($P < 0.05$). There were no differences in free insulin, glucagon, cortisol, or free fatty acids between MOD and IHE.

CONCLUSIONS — The decline in blood glucose levels is less with IHE compared with MOD during both exercise and recovery in individuals with type 1 diabetes.

Diabetes Care 28:1289–1294, 2005

Guelfi, et al. Diab Care 2005; 28:1289-1294

Intermittent High Intensity (•) vs. Moderate Intensity Exercise (o) in T1DM

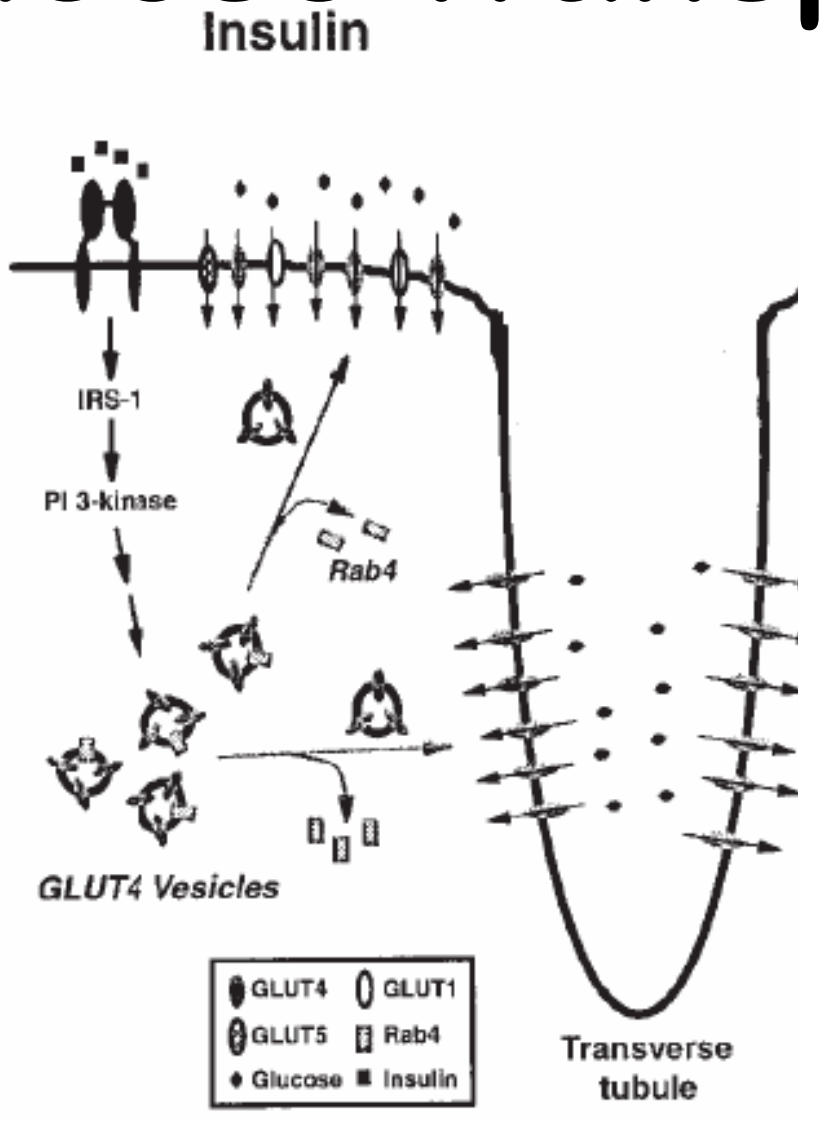


Guelfi, et al. Diab Care 2005; 28:1289-1294

Glucose Utilization During Exercise

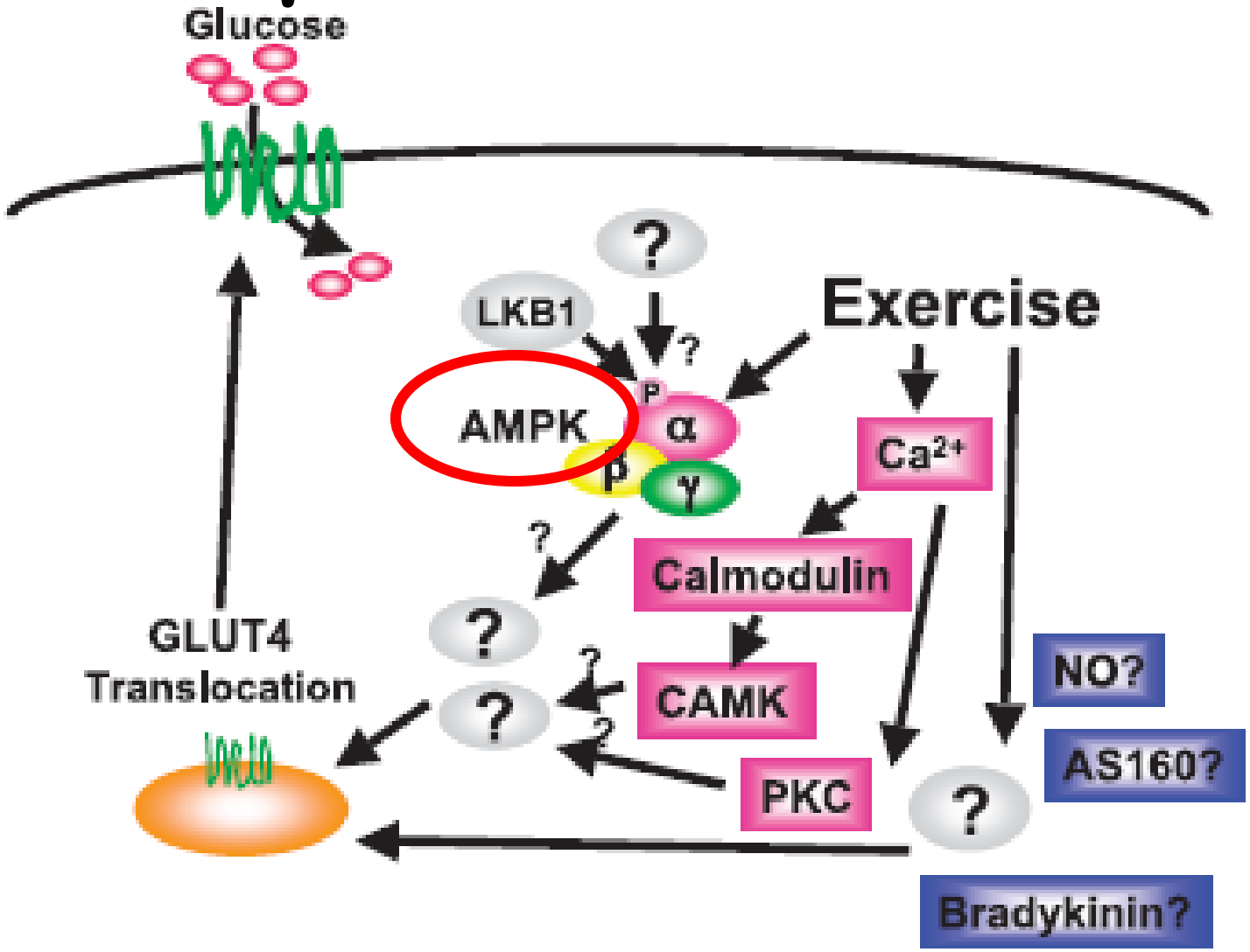
- Insulin-mediated glucose uptake
- Insulin-independent glucose uptake

Glucose Transport into Muscle



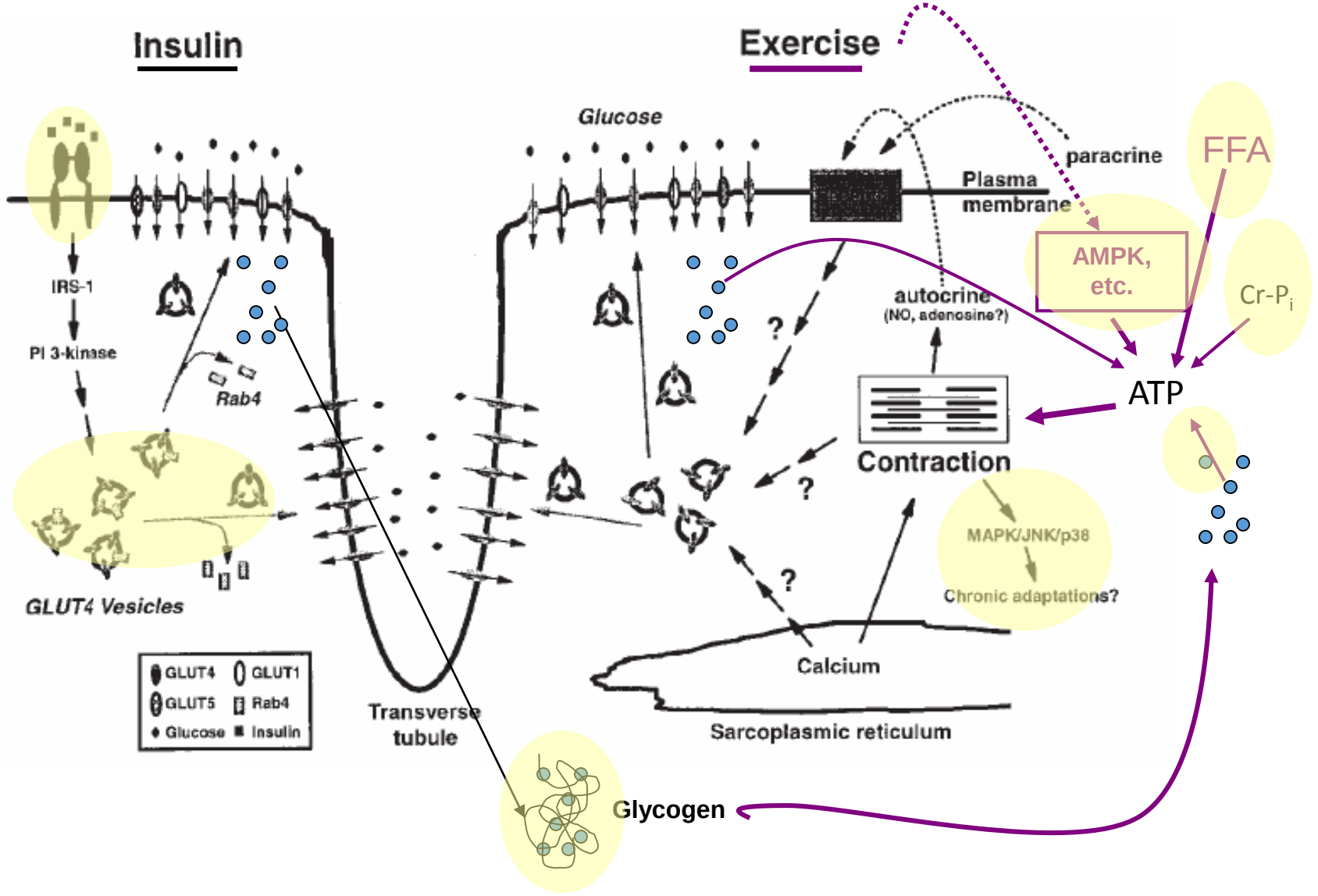
adapted from Goodyear & Kahn, Ann Rev Med, 1998

Biochemical Mechanism of Glucose Uptake with Exercise



Jessen & Goodyear. J Appl Physiol, 2005

Glucose Transport into Trained Muscle



adapted from Goodyear & Kahn, Ann Rev Med, 1998

Basic Exercise Carbohydrate Metabolism

- Muscle metabolism
  - Stored glycogen (“20-30 minutes”)
  - Insulin dependent glucose uptake and enhanced insulin sensitivity
  - Insulin-independent glucose uptake with exercise
  - Aerobic vs. anaerobic glycolysis
  - Fatty acid as fuel substrate
- Dietary carbohydrates supplement fuel through Blood Glucose
- Endogenous glucose production maintains blood glucose
  - Hepatic glycogenolysis
  - Gluconeogenesis

Benefits of Exercise in Diabetes

- Preventive benefits
- Glycemic benefits
- Reduction in complications
- Mortality benefit
- Benefits unrelated to diabetes

Prevention of Type 2 Diabetes

Diet + Exercise Intervention for IGT

	Reduction in progression to diabetes (%)
Diabetes Prevention Program	
N=3234, 2.8 years Low-fat diet + exercise	58
Finnish Study	
N=522, 3.2 years Low-fat diet + exercise	58
Da Qing Study	
N=577, 6.0 years Diet and/or exercise	31–46

DPP Research Group. *N Engl J Med.* 2002;346:393-403; Tuomilehto J et al. *N Engl J Med.* 2001;344:1343-1350; Pan XR et al. *Diabetes Care*. 1997;20:537-544

Prevention of Type 2 Diabetes

Lifestyle Intervention

- Nutrition
  - Seek 5% to 7% weight reduction
    (50% and 43% achieved this in Diabetes Prevention Program and Finnish trials, respectively)
  - <30% calories from fat

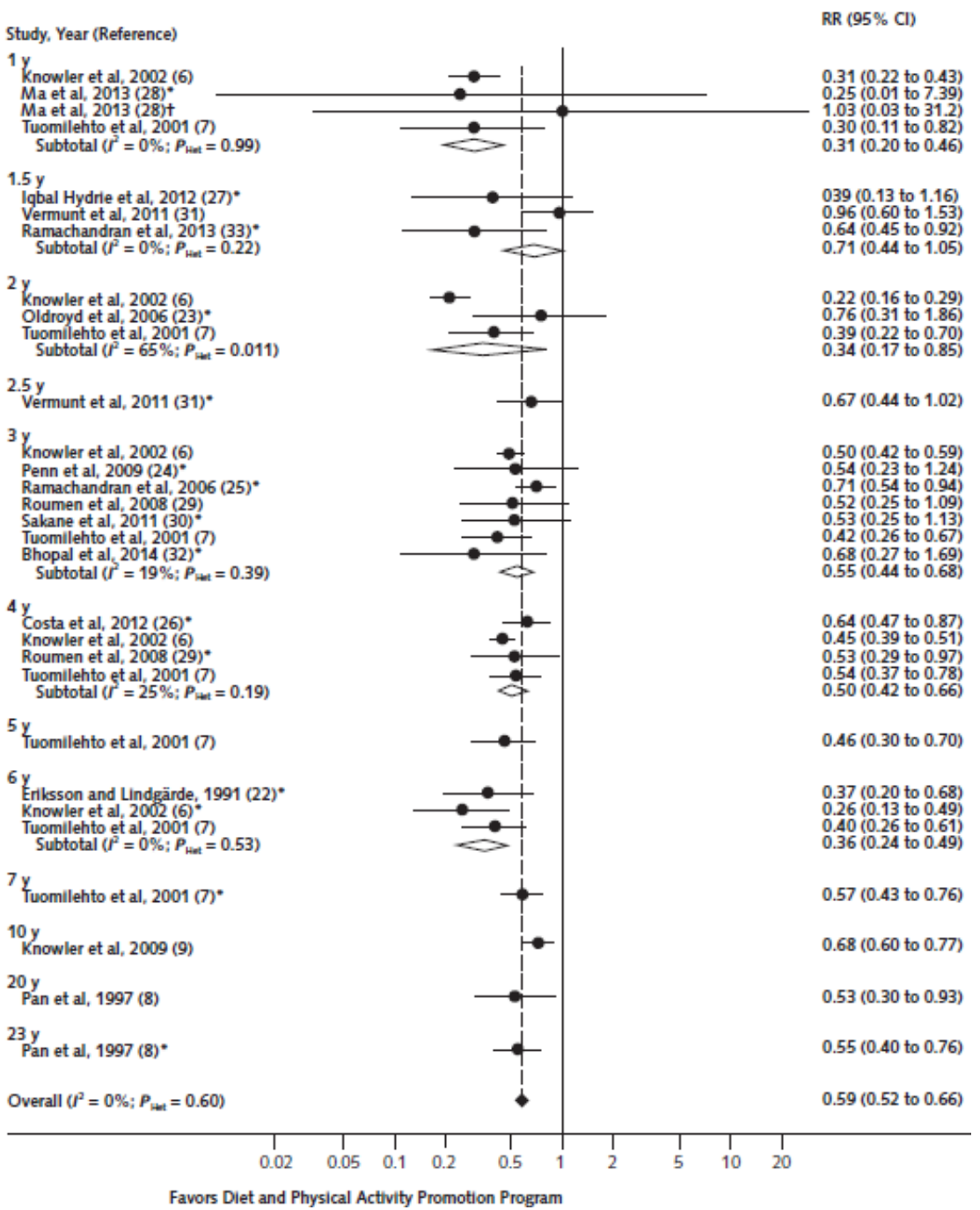
- Physical activity
  - Moderate exercise, 150 to 210 min/week
    (equivalent to 30-min sessions 5 to 7 days/week;
    74% and 86% achieved this in Diabetes Prevention Program and Finnish trials, respectively)

DPP Research Group. *N Engl J Med.* 2002;346;393-403;
Tuomilehto J et al. *N Engl J Med.* 2001;344:1343-1350

Physical Activity Prevents T2DM

Type 2 Diabetes Among Persons at Increased Risk: A Systematic Review for the Community Preventive Services Task Force

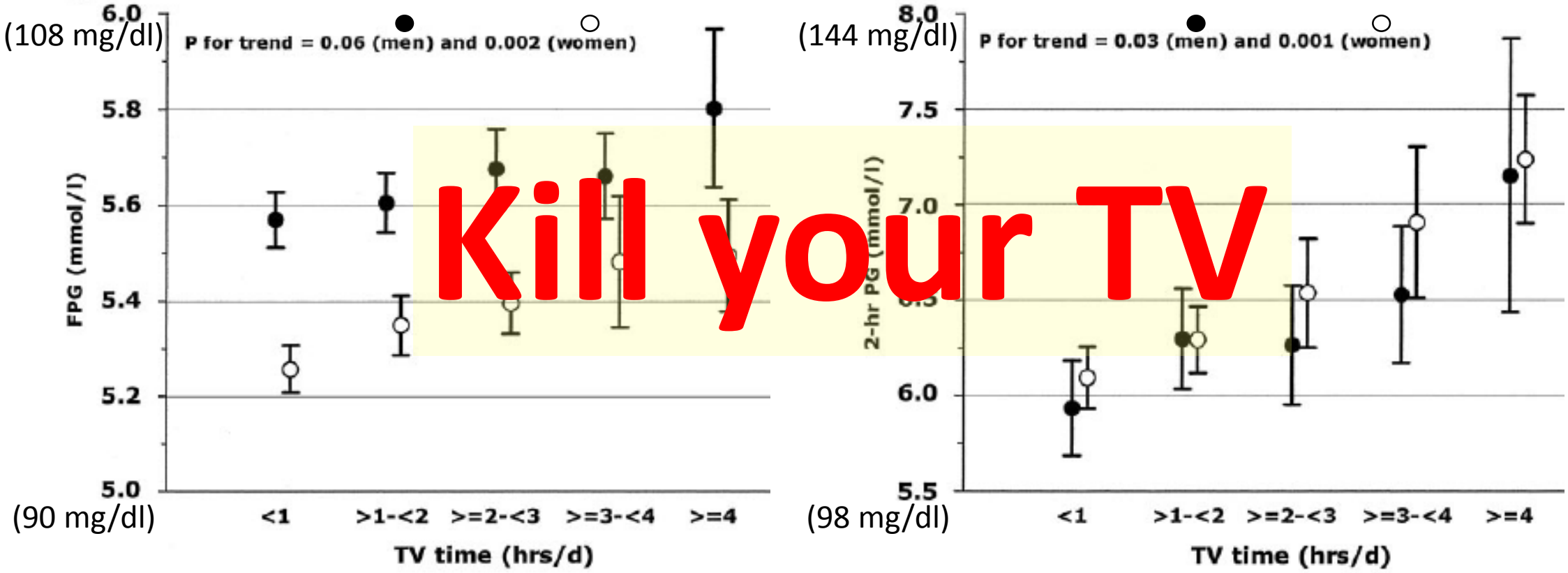
- Combined diet and physical activity promotion programs are effective at decreasing diabetes incidence and improving cardiometabolic risk factors in persons at increased risk
- 53 studies
- Variable effects per intensity
- **More intensive programs are more effective**
- Overall reduction ~40%



Balk, et al. Ann Intern Med. 2015;163:437-451

Sedentary time is bad for glucose control

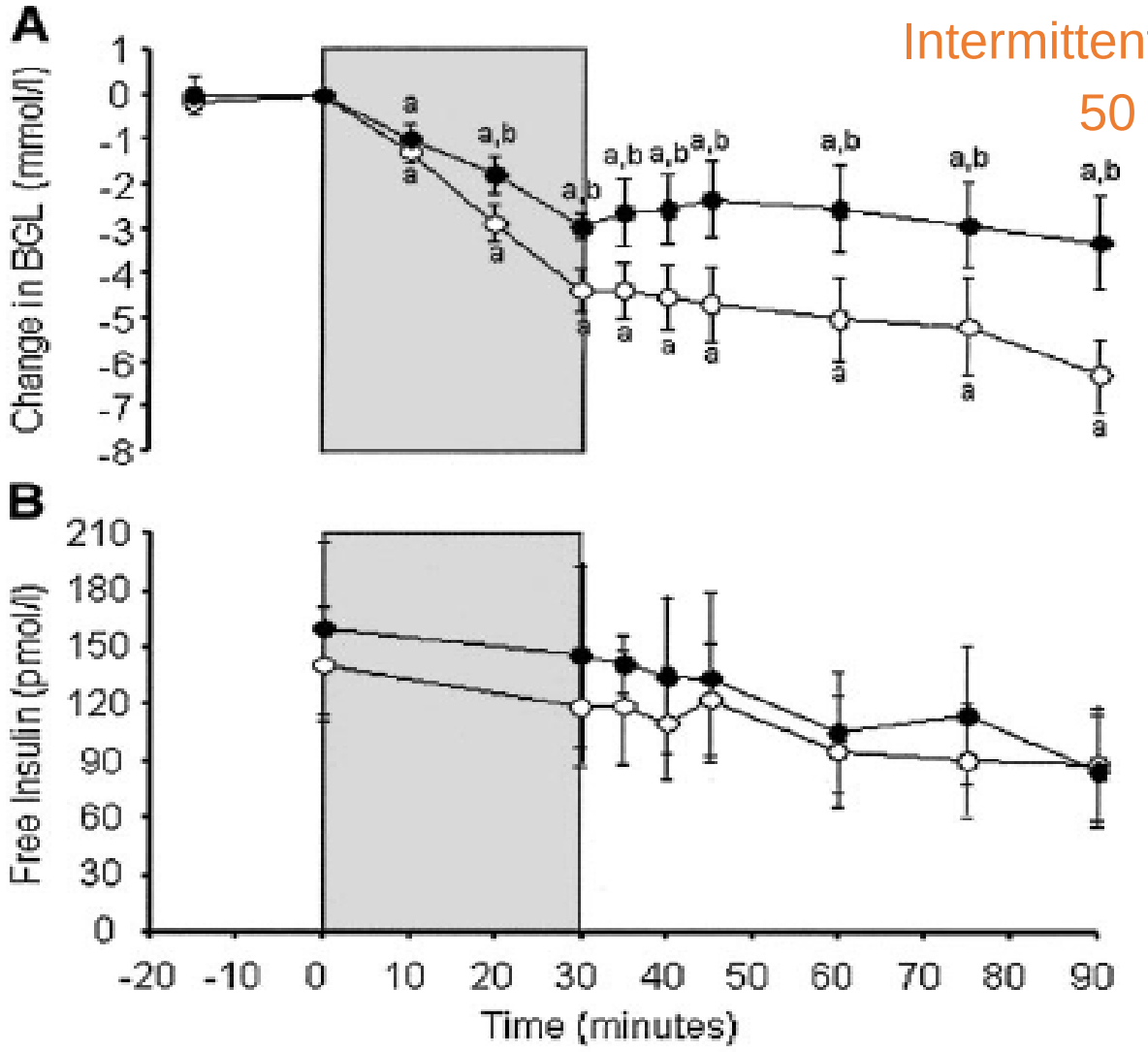
(>8300 subjects without diabetes in AusDiab)



Kill your TV

Dunstan, et al, AusDiab. Diabetes Care 30:516–522, 2007

Exercise Decreases BG in DM



Intermittent High Intensity Exercise •

50 mg/dl

100 mg/dl

Moderate Exercise °

Intermittent High Intensity Exercise (•) vs. Moderate Intensity Exercise (o) in T1DM

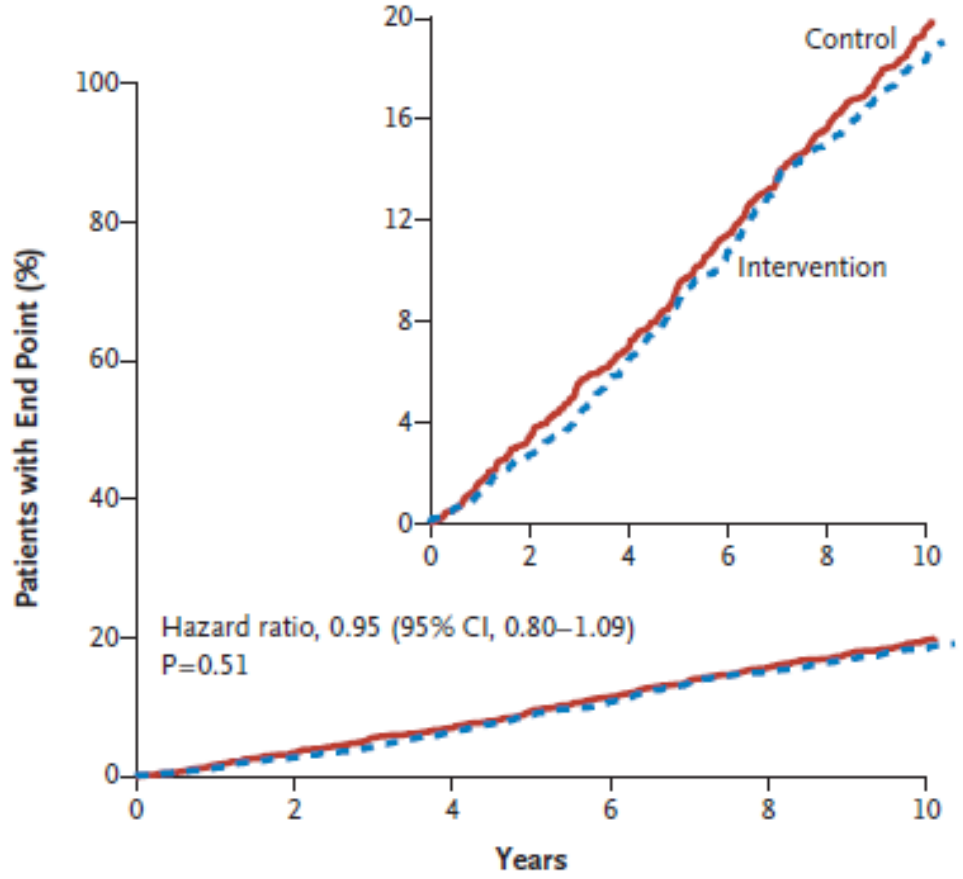
Guelfi, et al. Diab Care 2005; 28:1289-1294

Aerobic, Resistance and Combined Exercise Effects on Glycemia

	Mode of exercise		
	Aerobic	Resistance	Combined
A1C	−0.37 ± 0.16 small	−0.29 ± 0.25 small	−0.43 ± 0.29 small
Fasting glucose	−0.20 ± 0.15 small	−0.10 ± 0.31 unclear	−0.53 ± 0.31 small
Postprandial glucose*	*−0.44 ± 0.20* *small*	*−0.10 ± 0.53* *unclear*	*−0.28 ± 0.46* *small*
Insulin sensitivity	0.74 ± 0.47 moderate	0.34 ± 0.52 small	2.20 ± 1.85 large

Snowling & Hopkins. Diabetes Care 29:2518–2527, 2006

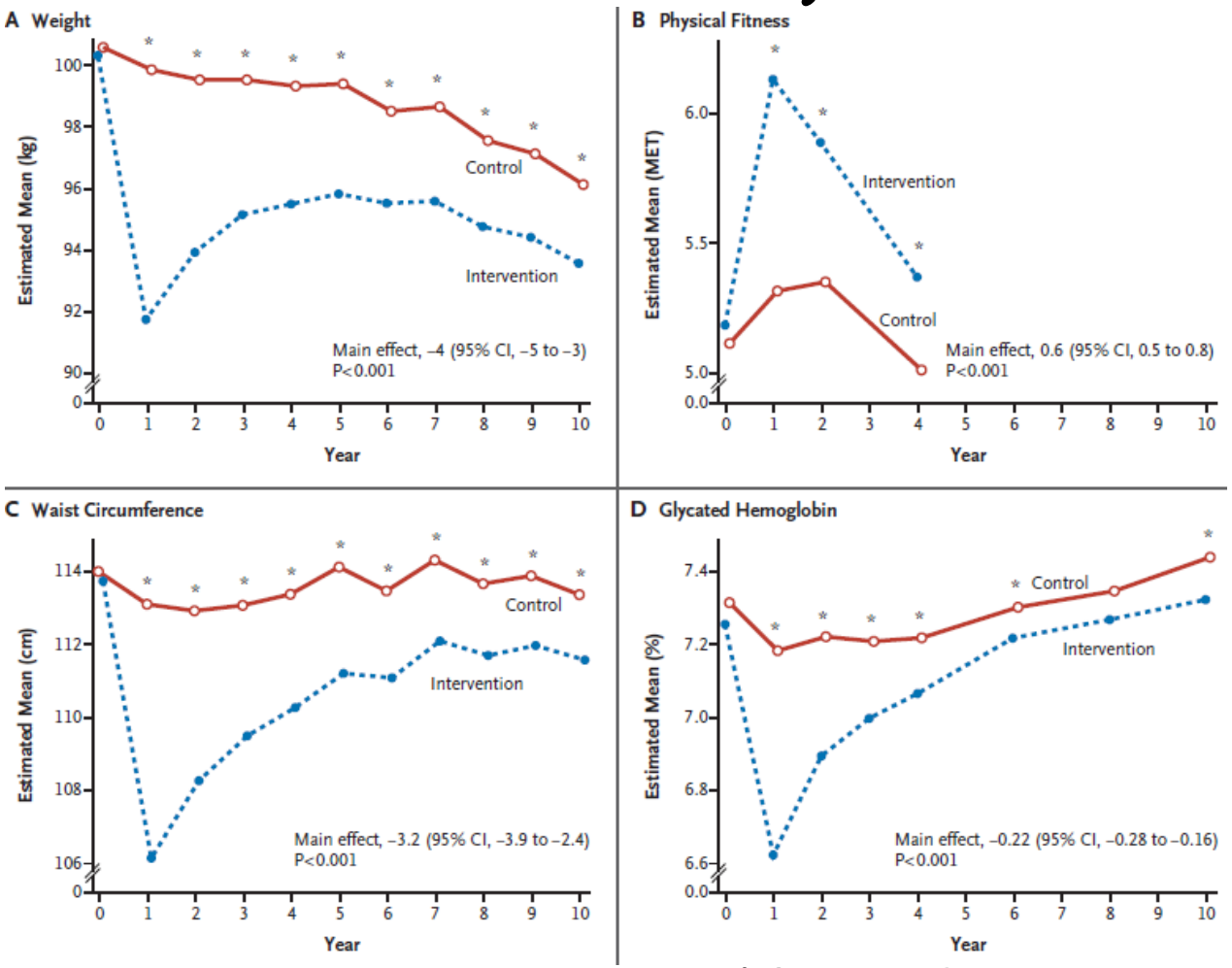
Physical Activity in Type 2 Diabetes: Look AHEAD "a negative trial"



"At a median follow-up of almost 10 years, there was no significant difference between the two groups in cardiovascular morbidity and mortality"

Look AHEAD Research Group – Wing, et al. N Engl J Med. 2013, 369(2):145-54

Physical Activity in Type 2 Diabetes: Look AHEAD, *not* "a negative trial"?



- weight loss
- cardiorespiratory fitness
- blood glucose control
- blood pressure
- lipids with fewer medications
- severe diabetic kidney disease and retinopathy
- sleep apnea
- depression
- sexual dysfunction
- urinary incontinence
- knee pain
- physical mobility maintenance
- quality of life
- lower overall health care costs

Pi-Sunyer. Curr Nutr Rep. 2014; 3(4): 387–391

Look AHEAD Research Group – Wing, et al. N Engl J Med. 2013; 369(2):145-54

Effects of Total Physical activity on Mortality and CVD in T2DM (prospective data)

Variable	Inactive	Moderately Inactive	Moderately Active	Active	*P* Trend
		Total Physical Activity[a]			
Total mortality					
Cases/PY	304/15 941	271/17 230	115/10 768	119/9253	
Incidence rate per 1000 PY	19.1	15.7	10.7	12.9	
Sex-adjusted HR (95% CI)[b]	1 [Reference]	0.64 (0.53-0.76)	0.53 (0.42-0.66)	0.62 (0.50-0.78)	<.001
Multivariable HR (95% CI)[c]	1 [Reference]	0.69 (0.57-0.83)	0.62 (0.49-0.78)	0.74 (0.59-0.94)	.001
Multivariable HR (95% CI)[d]	1 [Reference]	0.68 (0.54-0.66)	0.58 (0.43-0.77)	0.81 (0.61-1.08)	.03
CVD mortality					
Cases/PY	99/15 941	61/17 230	27/10 768	25/9253	
Incidence rate per 1000 PY	6.2	3.5	2.5	2.7	
Sex-adjusted HR (95% CI)[b]	1 [Reference]	0.59 (0.43-0.82)	0.40 (0.26-0.63)	0.53 (0.34-0.85)	.001
Multivariable HR (95% CI)[c]	1 [Reference]	0.65 (0.46-0.91)	0.51 (0.32-0.81)	0.62 (0.38-1.01)	.004
Multivariable HR (95% CI)[d]	1 [Reference]	0.46 (0.28-0.74)	0.31 (0.15-0.60)	0.48 (0.25-0.94)	.001

Increasing total activity improves mortality and CVD mortality in the EPIC Study of >5800 subject followed for median 9.4 years

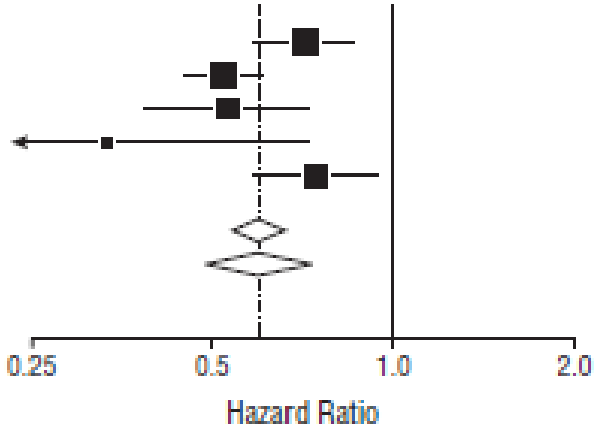
Sluik, et al. Arch Intern Med. 2012;172(17):1285-1295

Effects of Total Physical activity on Mortality and CVD in T2DM (meta analysis)

Mortality

Source	Population	HR (95% CI)
Gregg et al,[15] 2003	National Health Interview Survey, United States	0.71 (0.58-0.86)
Hu et al,[32] 2005	Population surveys, Finland	0.52 (0.45-0.60)
Joniker et al,[21] 2006	Framingham Heart Study, United States	0.53 (0.39-0.72)
Trichopoulou et al,[34] 2006	EPIC, Greece	0.33 (0.16-0.71)
Present study	EPIC, Europe	0.74 (0.59-0.93)
Combined fixed-effects model		0.59 (0.54-0.66)
Combined random-effects model		0.60 (0.49-0.73)

Heterogeneity: I^2=69% (95% CI, 19%-88%), Q=12.71; (P=.01)

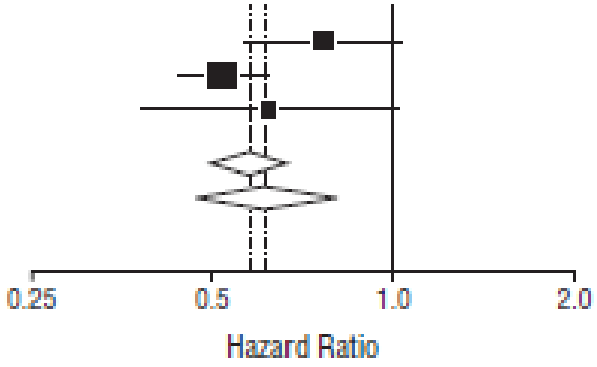


B

CVD Mortality

Source	Population	HR (95% CI)
Gregg et al,[15] 2003	National Health Interview Survey, United States	0.76 (0.57-1.02)
Hu et al,[32] 2005	Population surveys, Finland	0.52 (0.44-0.62)
Present study	EPIC, Europe	0.62 (0.38-1.01)
Combined fixed-effects model		0.58 (0.50-0.66)
Combined random-effects model		0.61 (0.47-0.80)

Heterogeneity: I^2=59% (95% CI, 0%-88%), Q=4.83; (P=.09)



Sluik, et al. Arch Intern Med. 2012;172(17):1285-1295

Potential Harms of Exercise

- Hypoglycemia
- Injuries
- Special considerations
  - Retinopathy
  - Foot problems
  - Heart Disease

Diabetes Treatment Considerations with Exercise

- Know what to expect
- Oral agents
- Insulin
- Adjusting carbohydrate intake
- Changing methods of exercise
- Intensity and duration

Diabetes Treatment Considerations with Exercise

- Oral and non-insulin agents
  - Sulfonyl-ureas – risk of hypoglycemia
  - Metformin – risk of lactic acidosis, ?late low glucose
  - Thiazoladinediones- no noted risks
  - Acarbose – simple sugar for carbohydrate supplement
  - DPP4-inhibitors – no noted risks
  - SGLT-2 inhibitors – avoid dehydration
  - GPL1-receptor agonists – no noted risks
- Insulin
- Adjusting carbohydrate intake
- Changing methods of exercise
- Intensity and duration

Diabetes Treatment Considerations with Exercise

- Oral agents
- Insulin
- Adjusting carbohydrate intake
- Changing methods of exercise
- Intensity and duration

Diabetes Treatment Considerations with Exercise

- Insulin (+risk of hypoglycemia)
  - Expect greater insulin sensitivity
  - Reduce basal insulin if feasible
  - Reduce pre-exercise meal bolus if feasible
  - Be consistent
  - Be ready to supplement with carbohydrate

Diabetes Treatment Considerations with Exercise

- Insulin (+risk of hypoglycemia)
  - Expect greater insulin sensitivity
  - Reduce pre-exercise meal bolus if feasible

Table 2—Suggested initial pre-exercise meal insulin bolus reduction for activity started within 90 min after insulin administration

	Exercise duration	
Exercise intensity	30 min	60 min
Mild aerobic (~25% VO_{2max})	−25%*	−50%
Moderate aerobic (~50% VO_{2max})	−50%	−75%
Heavy aerobic (70%−75% VO_{2max})	−75%	N-A
Intense aerobic/anaerobic (>80% VO_{2max})	No reduction recommended	N-A

Physical Activity/Exercise and Diabetes: A Position Statement of the ADA. Diabetes Care 2016;39:2065–2079

Diabetes Treatment Considerations with Exercise

- Oral agents
- Insulin
- Adjusting carbohydrate intake
- Changing methods of exercise
- Intensity and duration

Diabetes Treatment Considerations with Exercise

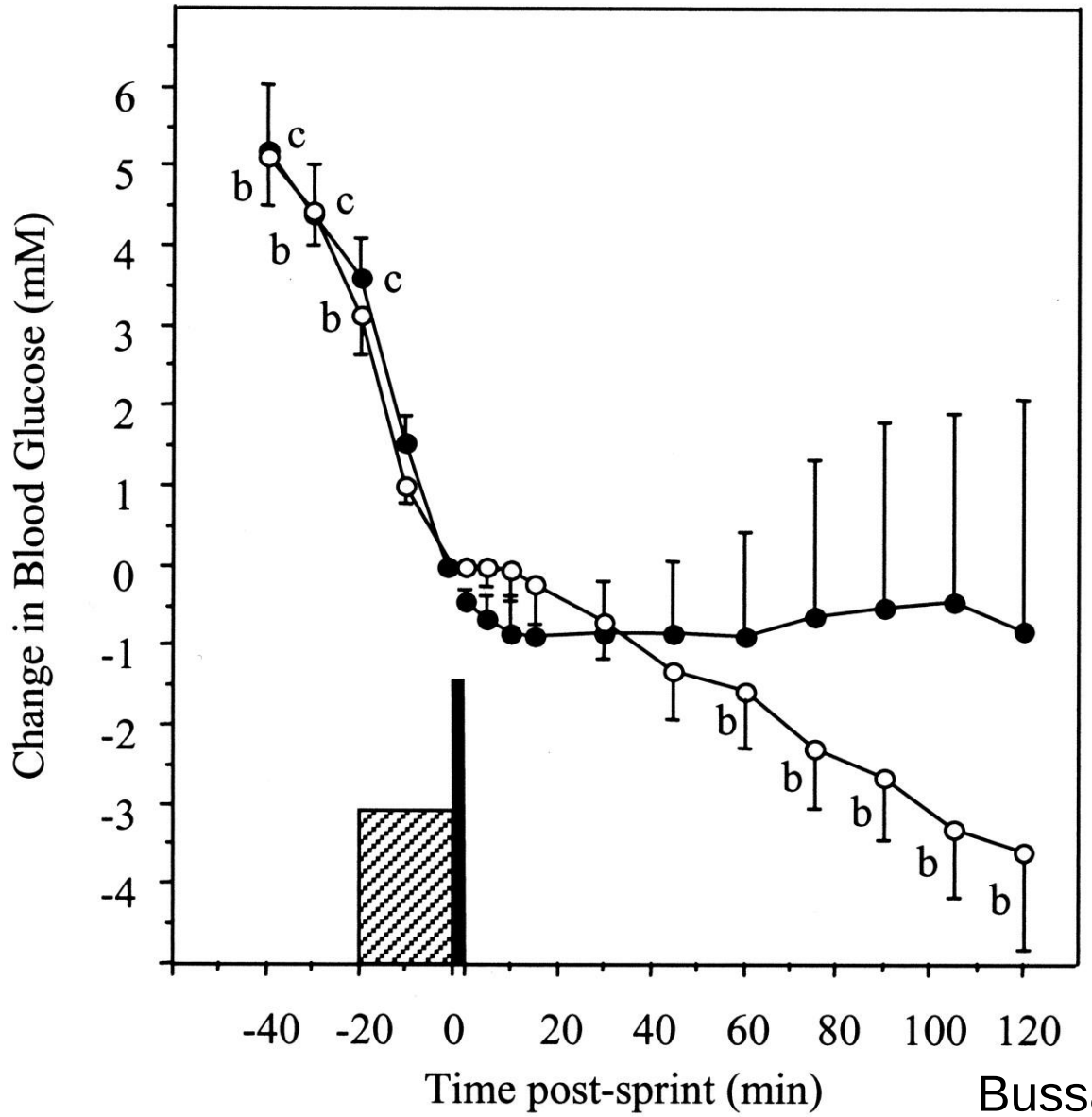
- Adjusting carbohydrate intake
  - ➢ Ingest 0.5-1 g/kg of carbohydrate per hour of exercise
  - ➢ Depends on intensity
  - ➢ May require 15-30 g bolus up-front, especially if starting blood sugar is low

Physical Activity/Exercise and Diabetes: A Position Statement of the ADA. Diabetes Care 2016;39:2065–2079

Diabetes Treatment Considerations with Exercise

- Oral agents
- Insulin
- Adjusting carbohydrate intake
- Changing methods of exercise
- Intensity and duration

Effect of 10-s sprint on blood glucose after moderate-intensity exercise



● +10 s. sprint

o control

American Diabetes Association.

Bussau et al. Diab Care 2006;29:601-606

ADA Recommendations - 2016:

(those with strongest support – A&B)

- All adults, and particularly those with type 2 diabetes, should decrease the amount of time spent in daily sedentary behavior. **B**
- Daily exercise, or at least not allowing more than 2 days to elapse between exercise sessions, is recommended to enhance insulin action. **B**
- Structured lifestyle interventions that include at least 150 min/week of physical activity and dietary changes resulting in weight loss of 5%–7% are recommended to prevent or delay the onset of type 2 diabetes in populations at high risk and with prediabetes. **A**

Physical Activity/Exercise and Diabetes: A Position Statement of the ADA. Diabetes Care 2016;39:2065–2079

ADA Recommendations - 2016:

(those with strongest support – A&B)

- Youth and adults with type 1 diabetes can benefit from being physically active, and activity should be recommended to all. **B**
- Blood glucose responses to physical activity in all people with type 1 diabetes are highly variable based on activity type/timing and require different adjustments. **B**
- Additional carbohydrate intake and/or insulin reductions are typically required to maintain glycemic balance during and after physical activity. Frequent blood glucose checks are required to implement carbohydrate intake and insulin dose adjustment strategies. **B**

Physical Activity/Exercise and Diabetes: A Position Statement of the ADA. Diabetes Care 2016;39:2065–2079

ADA Recommendations - 2016:

(those with strongest support – A&B)

- Pre-exercise medical clearance is generally unnecessary for asymptomatic individuals prior to beginning low- or moderate-intensity physical activity not exceeding the demands of brisk walking or everyday living. **B**
- Most adults with diabetes should engage in 150 min or more of moderate-to-vigorous intensity activity weekly, spread over at least 3 days/week, with no more than 2 consecutive days without activity. Shorter durations (minimum 75 min/week) of vigorous-intensity or interval training may be sufficient for younger and more physically fit individuals. **B** for type 2 diabetes
- Adults with diabetes should engage in 2–3 sessions/week of resistance exercise on nonconsecutive days. **B** for type 2 diabetes
- To gain more health benefits from physical activity programs, participation in supervised training is recommended over nonsupervised programs. **B**

Physical Activity/Exercise and Diabetes: A Position Statement of the ADA. Diabetes Care 2016;39:2065–2079

ADA Recommendations - 2016:

(those with strongest support – A&B)

- Insulin regimen and carbohydrate intake changes should be used to prevent exercise-related hypoglycemia. Other strategies involve including short sprints, performing resistance exercise before aerobic exercise in the same session, and activity timing. **B**
- Physical activity with vascular diseases can be undertaken safely but with appropriate precautions. **B**
- Physical activity done with peripheral neuropathy necessitates proper foot care to prevent, detect, and prevent problems early to avoid ulceration and amputation. **B**
- Targeted behavior-change strategies should be used to increase physical activity in adults with type 2 diabetes. **B**

Physical Activity/Exercise and Diabetes: A Position Statement of the ADA. Diabetes Care 2016;39:2065–2079

ADA Recommendations - 2016:

Table 3—Exercise training recommendations: types of exercise, intensity, duration, frequency, and progression

	Aerobic	Resistance	Flexibility and Balance
Type of exercise	• Prolonged, rhythmic activities using large muscle groups (e.g., walking, cycling, and swimming) • May be done continuously or as HIIT	• Resistance machines, free weights, resistance bands, and/or body weight as resistance exercises	• Stretching: static, dynamic, and other stretching; yoga • Balance (for older adults): practice standing on one leg, exercises using balance equipment, lower-body and core resistance exercises, tai chi
Intensity	• Moderate to vigorous (subjectively experienced as "moderate" to "very hard")	• Moderate (e.g., 15 repetitions of an exercise that can be repeated no more than 15 times) to vigorous (e.g., 6–8 repetitions of an exercise that can be repeated no more than 6–8 times)	• Stretch to the point of tightness or slight discomfort • Balance exercises of light to moderate intensity
Duration	• At least 150 min/week at moderate to vigorous intensity for most adults with diabetes • For adults able to run steadily at 6 miles per h (9.7 km/h) for 25 min, 75 min/week of vigorous activity may provide similar cardioprotective and metabolic benefits	• At least 8–10 exercises with completion of 1–3 sets of 10–15 repetitions to near fatigue per set on every exercise early in training	• Hold static or do dynamic stretch for 10–30 s; 2–4 repetitions of each exercise • Balance training can be any duration
Frequency	• 3–7 days/week, with no more than 2 consecutive days without exercise	• A minimum of 2 nonconsecutive days/week, but preferably 3	• Flexibility: ≥2–3 days/week • Balance: ≥2–3 days/week
Progression	• A greater emphasis should be placed on vigorous intensity aerobic exercise if fitness is a primary goal of exercise and not contraindicated by complications • Both HIIT and continuous exercise training are appropriate activities for most individuals with diabetes	• Beginning training intensity should be moderate, involving 10–15 repetitions per set, with increases in weight or resistance undertaken with a lower number of repetitions (8–10) only after the target number of repetitions per set can consistently be exceeded • Increase in resistance can be followed by a greater number of sets and finally by increased training frequency	• Continue to work on flexibility and balance training, increasing duration and/or frequency to progress over time

Physical Activity/Exercise and Diabetes: A Position Statement of the ADA. Diabetes Care 2016;39:2065–2079

Objectives

- Explain the effects of exercise on blood sugar
- Discuss benefits of exercise in patients with diabetes
- Analyze treatment considerations when exercising with diabetes

Questions?

My Approach:

- Get started
- 10 minutes, then advance to 45 minutes daily
- Be consistent
- Do what you can do
- Join a formal program
  - VA MOVE!
- Ask every visit

My Approach:

- Check blood sugar
- How much does it drop, determine safe starting point
- Too low, have some sugar
- Temporary Basals for pump users
- Reduce meal bolus before exercise by 25-50%
- Gel or exercise-drink during exercise
- Check blood sugar