How to Prescribe Exercise for Almost Anyone

Ronald J. Sigal, MD, MPH, FRCPC

Saturday, February 18, 2017

8:45 a.m. – 9:30 a.m.

This session will cover evidence on exercise regimes that are optimal and evidence –based, and take a practical approach to initiating, maintaining and increasing exercise in people with type 2 diabetes.

What types and amounts of exercise are recommended for people with diabetes? Why?

- People with diabetes should accumulate at least 150 minutes of moderate-to-vigourous aerobic exercise per week, spread over at least three days per week, with no more than two consecutive days without exercise.
- People with diabetes should perform resistance exercise at least twice per week, and ideally three times per week, in addition to aerobic exercise. Initial instruction and periodic supervision by an exercise specialist are recommended.

What is the minimal amount of exercise for which there is evidence of health benefits?

- Aerobic exercise volume as little as 75 minutes per week is associated with reduced mortality and other health benefits, but to a lesser extent than the 150 minutes normally recommended.
- Several studies found resistance exercise twice per week can improve glycemic control and strength, although greater improvements in these were seen in studies where resistance exercise was performed three times per week.

What is the role of high intensity interval training?

- Several short-term trials found that high intensity interval training increased aerobic fitness more than a similar volume of continuous moderate-intensity aerobic exercise, in spite of lower time requirements.
- Data in people with diabetes are limited but promising.

What to recommend for people with very low baseline fitness, arthritis and/or obesity limiting physical activity?

- Start with very small amounts of activity (e.g. 5 minutes per day), increase gradually.
- Consider water-based exercise if weight-bearing or arthritis limits physical activity.

How important is it to avoid sedentary behaviour?

- In primarily non-diabetic populations, there is increasing evidence from cohort studies that prolonged sitting is associated with higher risks of cardiovascular disease and death, even in people who exercise regularly.
- Randomized trial data, and data specifically on people with diabetes, are limited.

What strategies can enhance initiation and maintenance of exercise?

- Setting specific, realistic, measurable goals.
- Self-monitoring (exercise logs, objective monitoring)
- Motivational interviewing/motivational communication
- Developing strategies to overcome anticipated barriers.

References:

1. Colberg SR, Sigal RJ, Yardley JE, Riddell MC, Dunstan DW, Dempsey PC, Horton ES, Castorino K, Tate DF. Physical Activity/Exercise and Diabetes: a position statement of the American Diabetes Association. Diabetes Care 2016 Nov;39(11), 2065-2079.
2. Mendes R, Sousa N, Almeida A, Subtil P, Guedes-Marques F, Reis VM, Themudo-Barata JL. Exercise prescription for patients with type 2 diabetes-a synthesis of international recommendations: narrative review. Br J Sports Med 2016 Nov:50(22):1379-1381.

How to prescribe exercise to almost anyone

Ronald J. Sigal, MD, MPH, FRCPC rsigal@ucalgary.ca
Professor of Medicine, Cardiac Sciences, Kinesiology & Community Health Sciences,
Cumming School of Medicine, University of Calgary
Co-Chair, Professional Section, Diabetes Canada

Presenter Disclosure

- ***Dr. Ron Sigal*** perceives no conflict of interest with this presentation but has worked with or consulted for:
- **Grants/Research Support: Amilyn Pharmaceuticals, Merck Pharmaceuticals, Boehringer-Ingelheim, Eli Lilly (Site PI for multicentre trials)**
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Marni Armstrong, PhD
Author of slides with black background

Patient 1: T2DM, otherwise straightforward

"I'm not very active now, but know I should be."

"I have no mobility limitations, and have a reasonable amount of free time and discretionary income."

Patient 2: T2DM, time-challenged

"I know I should be physically active, but I don't have enough time"

Patient 3: T1DM, wants to avoid hypoglycemia

"I have type 1 diabetes. I try to exercise but I am having far too much hypoglycemia."

Patient 4: T2DM, mobility limitation

"My physical activity is limited because of my arthritis".

Patient 5: Peripheral neuropathy

"My peripheral neuropathy is so bad that I have very little sensation in my feet.

"My new girlfriend wants me to take brisk walks with her, and maybe eventually start jogging. Would this be ok?"

Exercise

- Planned, structured physical activity.

Types of exercise

Aerobic exercise

- Exercise involving continuous, repeated movements of large muscle groups.
- E.g. brisk walking, running, bicycling

Resistance exercise (strength training)

- Exercise involving weight lifting or movement of muscles against resistance
- E.g. exercise with free weights, weight machines

Outline

- What types and amounts of exercise are recommended? Why?
- What is the minimal amount of exercise for which there is evidence of health ?
- What is the role of high intensity interval training?
- How important is it to avoid sedentary behaviour?

Outline (2)

- What strategies can minimize risk of hypoglycemia in type 1 diabetes?
- What to recommend for people with very low fitness, arthritis, and/or obesity limiting activity?
- What strategies can enhance initiation and maintenance of exercise?

2016 ADA Position Statement

- 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.
- Shorter durations (min. 75 min/week) of vigorous-intensity or interval training may be sufficient for younger and more physically fit individuals.

Colberg S, Sigal RJ et al, *Diabetes Care 2016; 39:2065–2079.*

2016 ADA Position Statement

- Resistance training 2-3 times per week, in addition to aerobic training.
- Increase total daily incidental (non-exercise) physical activity and break up prolonged sedentary time.

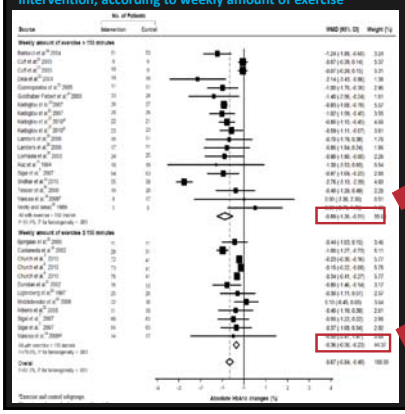
Why 150 minutes of aerobic exercise?

Why 150 minutes?

- 2008 US Physical Activity Guidelines Advisory Committee Report:
- For studies classifying subjects by energy expended, it appears that some 1,000 kilocalories per week or 10 to 12 MET-hours per week (approximately equivalent to 2.5 hours per week of moderate-intensity activity) or more is needed to significantly lower the risk of:
  - all-cause mortality
  - coronary heart disease
  - stroke
  - hypertension
  - type 2 diabetes

Evidence from trials in type 2 diabetes

Absolute changes in HbA1C of individual studies – structured exercise training vs. no intervention, according to weekly amount of exercise



Umpierre, JAMA, 2011; 305, (17); 1790-99

Reduction of -**0.89%** in HbA1C

Reduction of **0.36%** in HbA1C

Are strength and resistance training clinically important?

Strength is clinically important

- Biological aging: lose strength and lean body mass
- Older patients with type 2 diabetes have an accelerated decline in muscle mass and strength when compared with age-matched non-diabetic controls
- Strategies to maintain muscular strength enhance mobility and <u>functional independence</u> further into old age are important

Strength and mortality: Cohort study

- Large long-term cohort study: bottom tertile of strength was associated with:
  - 23% higher all-cause mortality
  - 32% higher cancer mortality
  - 29% higher CVD mortality

Ruiz JR. BMJ 2008; 337:a439.
Ruiz JR. Cancer Epidemiol Biomarkers Prev Med 2009;18(5):1468-1476.

Resistance training and mortality: cohort study

Large long-term cohort study:

- Regular resistance training was independently associated with 23% reduction in CVD risk…
- even after adjustment for age, smoking, alcohol, diet, and all other physical activity.

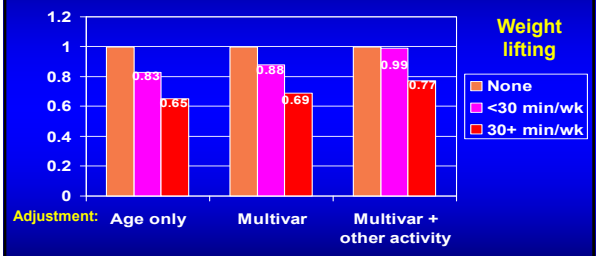
Tanasescu M. JAMA 2002; 288(16):1994-2000.
Tanasescu M. *Circulation* 2003;107(19):2435-2439.

Resistance exercise (weight training) and CHD

- Health Professionals Follow-up Study: 51,529 male health professionals aged 40-75 in 1986
- Competed health questionnaire (including physical activity questions) every 2 years.
- Weight training question starting 1990
- This analysis was on whole population, not just people with diabetes
- Excluded men with previous cardiovascular disease, cancer or mobility impairment.

Tanasescu M, JAMA 2002; 288:1994-2000

Weight training and risk of heart disease or stroke



Multivariate: adjusted for EtOH, smoking, family history of MI, nutrient intake

RCT evidence in type 2 diabetes

Jack Vitalis

- In a systematic review (7 trials) all but one study reported strength improvements of at least 50% after completing resistance training in people with type 2 diabetes. *Gordon, Diab Res Clin Prac. 2009;83(2):157-17*
- Meta-analysis (4 trials) reported 0.57% reduction in HbA1c in studies where resistance training alone was compared against a control. *Umpierre, JAMA, 2011; 305, (17); 1790-99*

Combined aerobic and resistance exercise is probably best

The Diabetes Aerobic and Resistance Exercise (DARE) Trial

RJ Sigal, GP Kenny, NG Boulé, RD Reid, D. Prud'homme, M. Fortier, D. Coyle, GA Wells

Funding:
Canadian Institutes of Health Research
Canadian Diabetes Association
Sigal RJ et al. Ann Intern Med 2007; 147:357-369.

DARE trial: Design

- Randomized, controlled trial
- 4-week pre-randomization run-in period to assess compliance

Randomization to

- Aerobic Training only
- Resistance Training only
- Both Aerobic and Resistance Training
- Waiting-list Control

Results: A1c (%)—changes over time

	Base-line	3 mo.	6 mo.	Change from 0-6 mo. Adj mean (95% CI)	P-value
Combined n=64 (40M,24F)	7.46 (1.48)	6.99 (1.56)	6.56 (0.88)	-0.90 (-1.15 to -0.64)	<0.001
Aerobic n=60 (39M,21F)	7.41 (1.50)	7.00 (1.59)	6.98 (1.50)	-0.43 (-0.70 to -0.17)	0.002
Resistance n=64 (40M,24F)	7.48 (1.47)	7.35 (1.57)	7.18 (1.52)	-0.30 (-0.56 to -0.05)	0.018
Control n=63 (41M,22F)	7.44 (1.38)	7.33 (1.49)	7.51 (1.47)	+0.07 (-0.18 to +0.32)	0.57

Results: A1c (%)—Baseline ≥7.5%

	Baseline	3 mo.	6 mo.	Change from 0-6 mo.	
				Adj mean (95% CI)	P-value
Combined n=30	8.44 (1.04)	7.64 (1.32)	7.02 (1.35)	-1.42 (-1.83 to -1.01)	<0.001
Aerobic n=28	8.31 (1.16)	7.51 (1.45)	7.47 (1.33)	-0.83 (-1.28 to -0.38)	<0.001
Resistance n=36	8.29 (1.14)	8.06 (1.48)	7.80 (1.42)	-0.49 (-0.87 to -0.10)	0.013
Control n=33	8.30 (1.03)	8.06 (1.38)	8.28 (1.39)	-0.02 (-0.40 to +0.36)	0.90

Results: A1c (%)—Baseline <7.5%

	Baseline	3 mo.	6 mo.	Change from 0-6 mo.	
				Adj mean (95% CI)	P-value
Combined n=34	6.93 (0.41)	6.76 (0.79)	6.48 (0.84)	-0.46 (-0.73 to -0.18)	0.002
Aerobic n=32	7.00 (0.40)	6.90 (0.78)	6.90 (0.79)	-0.10 (-0.38 to +0.19)	0.50
Resistance n=28	6.95 (0.37)	6.93 (0.78)	6.87 (0.82)	-0.08 (-0.38 to +0.22)	0.59
Control n=30	6.85 (0.33)	6.88 (0.75)	7.02 (0.81)	+0.17 (-0.11 to +0.46)	0.24

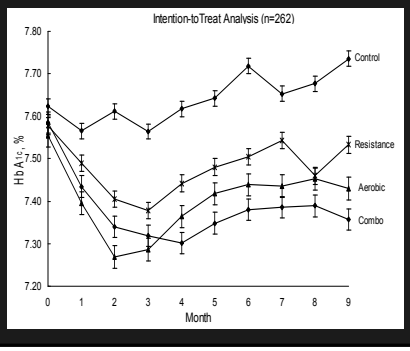
Health Benefits of Aerobic & Resistance Training in Individuals with Diabetes:
HART-D

Tim Church, M.D., M.P.H., Ph.D.
Pennington Biomedical Research Center

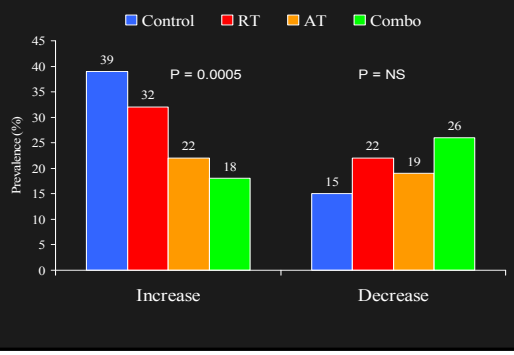
Church TS et al. JAMA. 2010 Nov 24;304(20):2253-62.

Thanks to Tim Church for HART-D slides

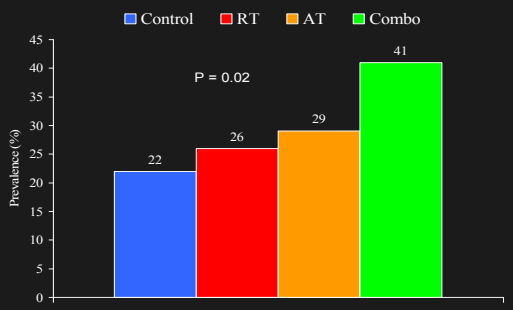
HART-D: Health Benefits of Aerobic & Resistance Training in Individuals with Diabetes *Church T, JAMA. Nov 24 2010;304(20):2253-2262.*



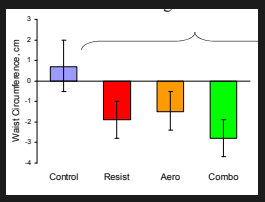
Changes in Diabetes Medications



Improve HbA1c ≥ 0.5% or Decrease DM Medications



Waist Circumference



What is the *incremental benefit* of gym-based supervised, structured exercise over that of physical activity counseling alone?

Italian Diabetes and Exercise Study

- 606 patients with type 2 diabetes and metabolic syndrome
- All received exercise counseling
- Randomized to control group (usual care plus exercise counseling) or intervention group (prescribed and supervised aerobic and resistance exercise training 2X/week) for 12 months

Balducci S et al, Arch Intern Med 2010

IDES: Supervised exercise was superior for

- HbA1c
- Systolic and diastolic blood pressure
- BMI
- Waist circumference
- Aerobic fitness
- Muscle strength
- HDL cholesterol
- Estimated 10-year cardiac risk

Action for HEAlth in Diabetes (Look-AHEAD)

Look AHEAD design and methods: Controlled Clinical Trials 2003; 24:610-628.

One year results: Diabetes Care 2007; 30:1374-83.

Four year results: Arch Intern Med 2010;170:1566-1575.

Main end-of-study results: NEJM 2013 Jul 11;369(2):145-54.

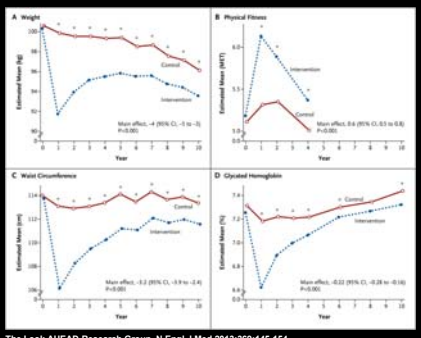
Review of key secondary outcomes:

Pi-Sunyer X. Curr Nutr Rep 2014;3:387–391.

Look AHEAD: objectives

- In overweight and obese patients with T2DM…
- to determine whether a 4-year intensive lifestyle intervention to reduce weight and increase physical activity will reduce CVD morbidity and mortality over up to 11.5 years of follow up.
- Secondary outcomes: A1C, body composition, fitness, lipids, BP, sleep quality, QOL, knee pain and numerous others

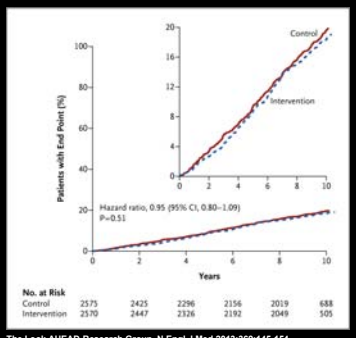
Changes in Weight, Physical Fitness, Waist Circumference, and Glycated Hemoglobin Levels during 10 Years of Follow-up.



The Look AHEAD Research Group. N Engl J Med 2013;369:145-154

The NEW ENGLAND JOURNAL of MEDICINE

Cumulative Hazard Curves for the Primary Composite End Point.



The Look AHEAD Research Group. N Engl J Med 2013;369:145-154

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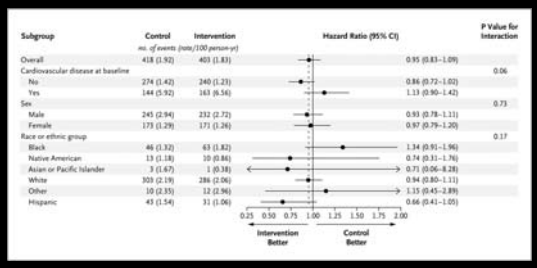
Primary Outcome in Prespecified Subgroups.



The Look AHEAD Research Group. N Engl J Med 2013;369:145-154

The NEW ENGLAND JOURNAL of MEDICINE

Look-AHEAD trial secondary outcomes-positive results

- Persistent, clinically significant weight loss.
- Decreased risk of renal disease.
- Decreased medical costs and hospitalizations.
- Decreased incidence of depression.
- Increase in fitness and physical functioning.
- Decreased sleep apnea.
- Decreased sexual dysfunction.

Possible explanations of lack of CVD risk reduction

- Maybe exercise and weight loss don't reduce CVD risk.
- More aggressive medical therapy (e.g. statins, ACE-Inhibitors) in control group.
- Lack of exercise supervision?
- Lack of resistance exercise training?

But your patient says:

"Doctor, that's a lot of time to devote to exercise."

"Do I really need to do that much? How little could I get away with?"

What are the minimal weekly amounts of aerobic and resistance exercise…

…for which there is *good evidence* of benefit in terms of *clinically-important outcomes*?

Some clinically-important outcomes

- Mortality
- Cardiovascular disease
- Type 2 diabetes

- Cardiorespiratory (aerobic) fitness
- HbA1c
- Quality of life

Evidence from a huge cohort study

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

Wen CP et al.
Lancet 2011; 378:1244-1253

Methods

- 416,175 people (199,265 men and 216 910 women) assessed in Taipei starting in 1996, followed through 2008 (average follow-up 8.05 years).
- Baseline questionnaire included questions on leisure-time physical activity (LTPA) over the previous month, assessing types of activities, intensity, duration.

Categories of physical activity volume (MET·hr/week)

Inactive	<3.75
Low volume	3.75 to <7.5
Medium volume	7.5 to <16.5
High volume	16.5 to <25.5
Very high volume	≥25.5

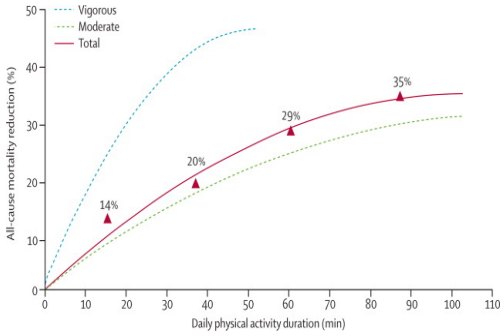


Figure 2 Daily physical activity duration and all-cause mortality reduction
Wen CP et al, Lancet 2011; 378:1244 - 1253

The low-volume group vs. inactive

- Low volume: Active 92 minutes/week (~13 min/day; rounded to 15 min by authors)
- Additional life expectancy vs. inactive: 3 years
- Each additional 15 min/day associated with 4% reduction in all-cause death (up to 100 min/day; no additional benefit beyond 100 min/day).

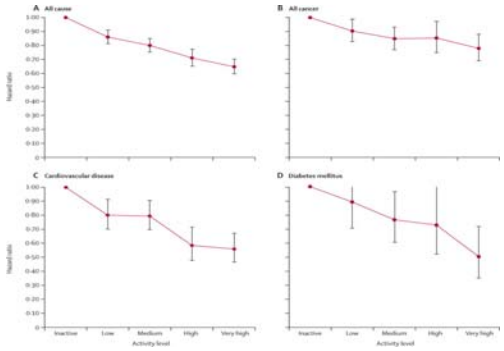


Figure 1 Relation between physical activity volume and mortality reduction compared with the inactive group Bars show 95% CIs. Wen CP Lancet 2011; 378:1244 - 1253

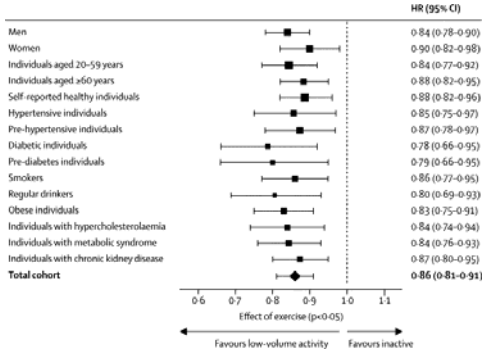
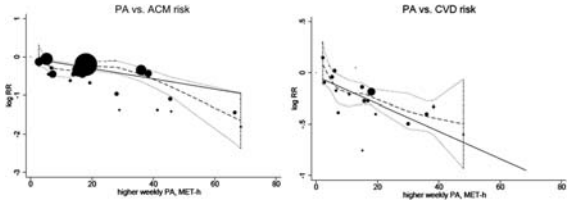


Figure 3. Adjusted all-cause mortality hazard ratio for individuals in the low-volume activity group compared with individuals in the inactive group, by participant characteristics. All hazard ratios (HR) are relative to health outcomes in the inactive group. Wen CP, Lancet 2011;378:1244 - 1253

Relationship between higher weekly PA and the logarithm (log RR) of ACM and CVD risk in patients with diabetes.



Kodama S et al. Diabetes Care 2013;36:471-479

American Diabetes Association.

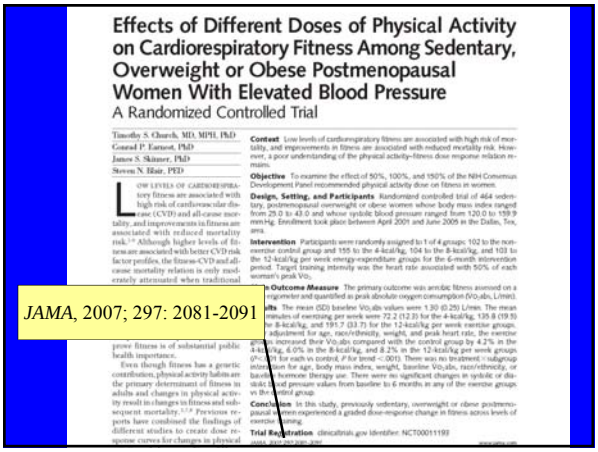
Limitations of this meta-analysis

- Different studies used different questionnaires
- Different studies quantified different aspects of activity even within the same activity type
- Imprecision/bias of self-report
- Cannot be sure of cause and effect

Evidence from a randomized trial

(Thanks to Dr. Tim Church for DREW trial slides)

Dose Response to Exercise in Women: DREW



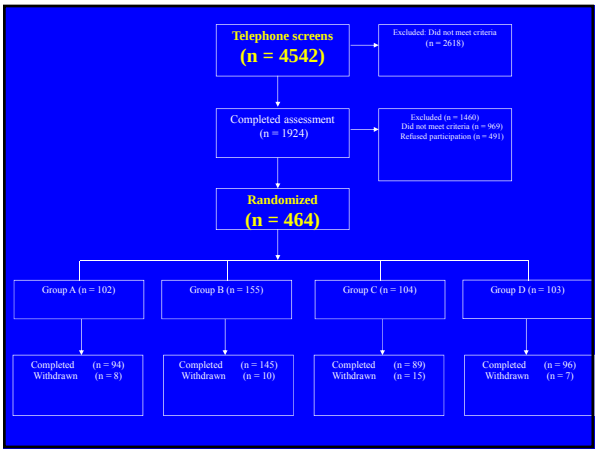
Effects of Different Doses of Physical Activity on Cardiorespiratory Fitness Among Sedentary, Overweight or Obese Postmenopausal Women With Elevated Blood Pressure

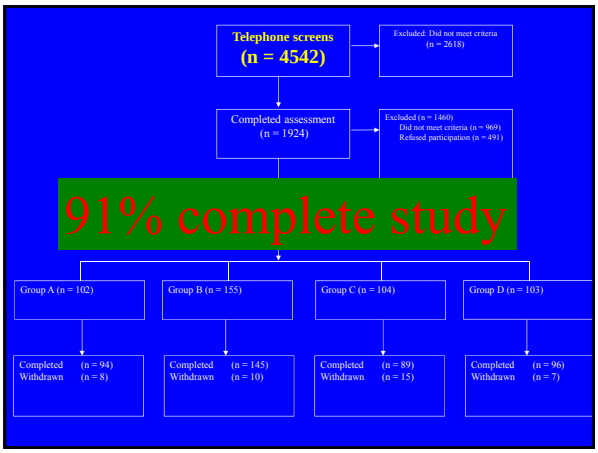
A Randomized Controlled Trial

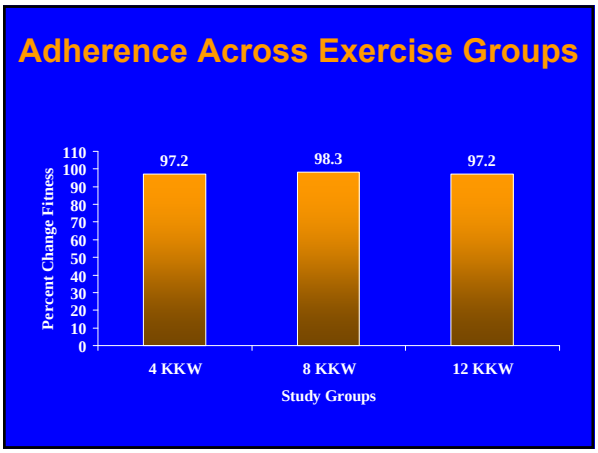
JAMA, 2007; 297: 2081-2091

Descriptives

Age	57.3 (6.4)
Caucasian	65%
HRT use	49%
SBP	139.0 (12.8) mmHg
DBP	80.4 (7.9) mmHg
VO_2 Max Absolute	1.3 (0.24) l/min
VO_2 Max Relative	15.6 (2.9) ml/kg/min
BMI	31.7 (3.8) kg/m2
Waist Circ	101.3 (11.9) cm
LDL	119.0 (26.7) mg/dl
HDL	57.5 (14.4) mg/dl
Triglycerides	131.6 (64.9) mg/dl
Glucose	95.1 (8.8) mg/dl
CRP	5.6 (5.5) mg/l







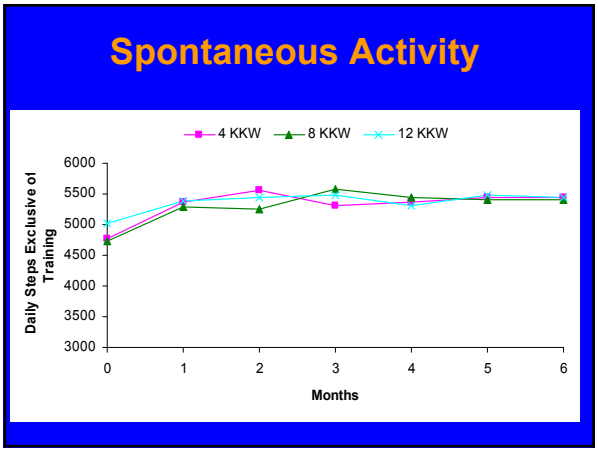
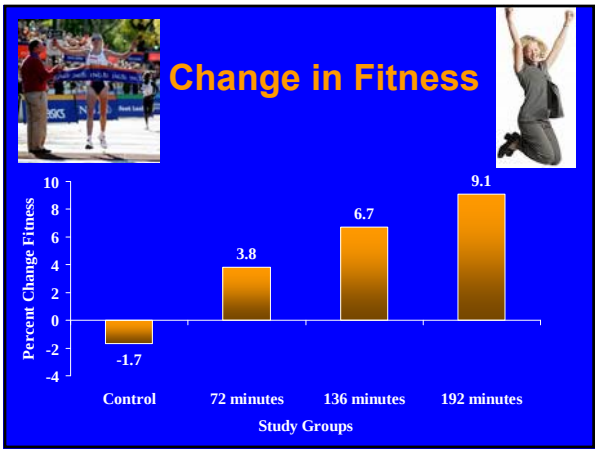
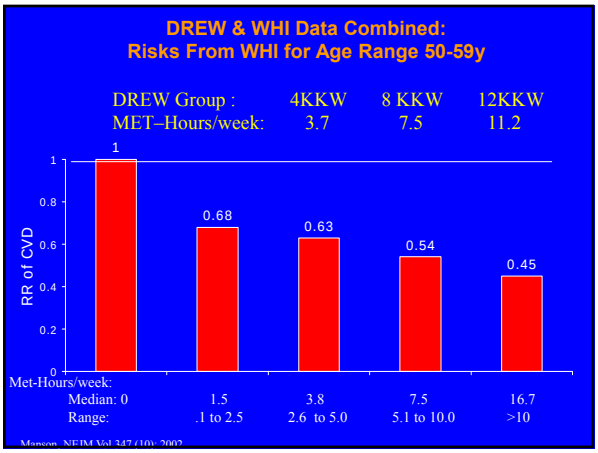


Table 2. Descriptive Training Data for Individuals Who Completed the Exercise Intervention*

	Exercise Groups		
	4 kcal/kg	8 kcal/kg	12 kcal/kg
Prescribed energy expenditure, kcal/wk†	335 (45)	681 (102)	1006 (132)
Time exercise, min/wk‡	72.2 (12.3)	135.8 (19.5)	191.7 (33.7
Average METs per session‡			
Cycle ergometer	3.8 (0.4)	3.8 (0.3)	3.9 (0.4)
Treadmill	3.1 (0.6)	3.3 (0.6)	3.5 (0.8)
Sessions/wk‡	2.6 (0.3)	2.8 (0.4)	3.1 (0.5)
6-mo adherence, %			
All	94.6 (16.6)	89.0 (25.6)	93.3 (20.3
Completers	98.0 (8.4)	97.8 (7.7)	97.4 (11.0

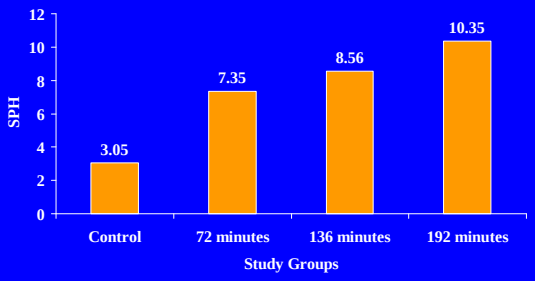
Abbreviation: METs, metabolic equivalents (1 MET = 3.5 mL O_2 uptake/kg per minute).
*All data are presented as mean (SD).
†Data for all participants and based on baseline weight.
‡Data for all individuals who completed the intervention. Data are for exercise training period excluding the initial ramp ing period which represents 6 months of data for the 4-kcal/kg, 5 months for the 8-kcal/kg, group, and 4 months fo the 12-kcal/kg week groups. Adherence was calculated for each individual by dividing the kilocalories expended during the 6-month exercise training by the kilocalories prescribed for the training period × 100%.



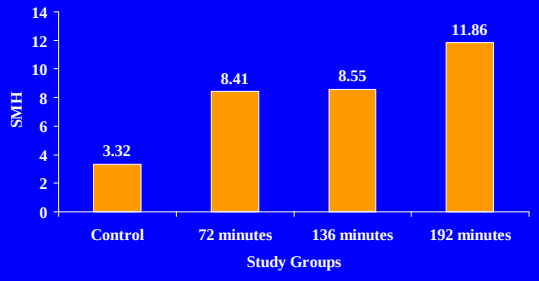


Quality of Life Measures

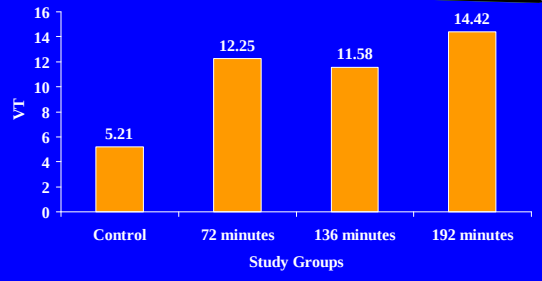
Change in Physical Health



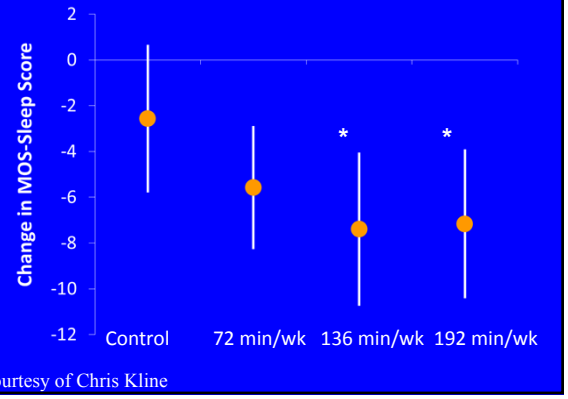
Change in Mental Health



Change in Energy



Sleep Disturbances subscale



Courtesy of Chris Kline

Summary

- Dose response between change in physical activity and change in fitness
- Even a small increase in physical activity (to 72 minutes) improves fitness and quality of life

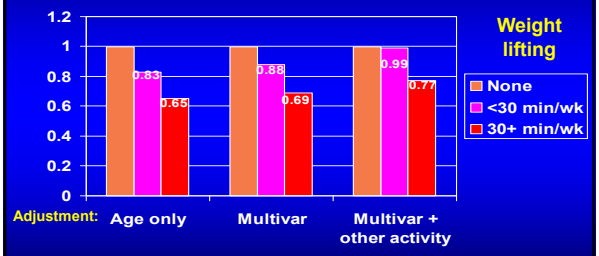
What about resistance exercise (weight lifting)?

Resistance exercise (weight training) and CHD

- Health Professionals Follow-up Study: 51,529 male health professionals aged 40-75 in 1986
- Competed health questionnaire (including physical activity questions) every 2 years.
- Weight training question starting 1990
- This analysis was on whole population, not just people with diabetes
- Excluded men with previous cardiovascular disease, cancer or mobility impairment.

Tanasescu M, JAMA 2002; 288:1994-2000

Weight training and risk of heart disease or stroke



Multivariate: adjusted for EtOH, smoking, family history of MI, nutrient intake

Aerobic vs. resistance exercise and HbA1c

Dose-response is not the same

DARE trial Results: A1c (%) changes over time

	Baseline	3 mo.	6 mo.	Change from 0-6 mo.	
				Adj mean (95% CI)	P-value
Combined n=64 (40M,24F)	7.46 (1.48)	6.99 (1.56)	6.56 (0.88)	-0.90 (-1.15 to -0.64)	<0.001
Aerobic n=60 (39M,21F)	7.41 (1.50)	7.00 (1.59)	6.98 (1.50)	-0.43 (-0.70 to -0.17)	0.002
Resistance n=64 (40M,24F)	7.48 (1.47)	7.35 (1.57)	7.18 (1.52)	-0.30 (-0.56 to -0.05)	0.018
Control n=63 (41M,22F)	7.44 (1.38)	7.33 (1.49)	7.51 (1.47)	+0.07 (-0.18 to +0.32)	0.57

HbA1c (%)-compliance>90%

	Baseline	3 months	6 months	Change Baseline to 6M	
				absolute	relative
Aerobic n=19 (10M,9F)	7.53 (0.76)	7.14 (0.68)	6.92 (0.75)	-0.62 (1.01)	-7.5% (12.3)
Resistance n=17 (10M,7F)	7.39 (0.72)	7.32 (0.93)	7.13 (0.68)	-0.26 (0.79)	-3.0% (10.6)
Combined n=26 (17M,9F)	7.72 (1.01)	7.03 (0.71)	6.63 (0.85)	-1.09 (1.2)	-13.0% (13.7)
Control n=63 (41M,22F)	7.66 (0.89)	7.55 (1.1)	7.72 (1.22)	+0.06 (1.02)	+1.1%

A1C (%)-compliance 75-90%

	Baseline	3 months	6 months	Change Baseline to 6M	
				absolute	relative
Aerobic n=17 (13M,4F)	7.55 (0.89)	7.06 (0.85)	7.18 (0.93)	-0.36 (1.02)	-4.2% (12.7)
Resistance n=29 (22M,7F)	7.91 (0.85)	7.85 (1.45)	7.65 (1.29)	-0.27 (0.90)	-3.5% (11.2)
Combined n=21 (16M,5F)	7.74 (0.94)	7.17 (1.22)	6.85 (0.89)	-0.89 (0.69)	-11.2% (8.2)
Control n=63 (41M,22F)	7.66 (0.89)	7.55 (1.1)	7.72 (1.22)	+0.06 (1.02)	+1.1%

Results: A1c (%)-compliance <75%

	Baseline	3 months	6 months	Change Baseline to 6M	
				absolute	relative
Aerobic n=24 (16M,8F)	7.90 (0.88)	7.52 (1.08)	7.55 (1.20)	-0.35 (1.14)	-4.0% (14.6)
Resistance n=17 (8M,9F)	7.71 (0.95)	7.42 (1.25)	7.27 (1.15)	-0.45 (0.70)	-5.8% (9.0)
Combined n=17 (7M,10F)	7.53 (0.73)	7.57 (0.80)	7.14 (0.89)	-0.39 (0.96)	-4.7% (11.8)
Control n=63 (41M,22F)	7.66 (0.89)	7.55 (1.1)	7.72 (1.22)	+0.06 (1.02)	+1.1%

So 150 minutes/week of aerobic exercise plus resistance exercise 2-3 times per week is best but…

…there is good evidence for the value of:

- Aerobic exercise 70-75 min/week
  - Mortality
  - CVD
  - Cardiorespiratory fitness
  - Quality of life
- Resistance exercise twice per week
  - CVD
  - HbA1c
  - Quality of life

What is the role of high intensity interval training?

Important barrier: TIME

- Recent interest in High Intensity Interval Training (HIIT)
- Alternating short bursts of high intensity with recovery or light exercise
- 90-100% of peak capacity
- Less time and more benefit?

High Intensity Interval Training

- Meta-analysis: *Weston, Br J of Sports Med 2014; 48:1227-1234*
- In patients with lifestyle-induced cardiometabolic disease
  - 10 studies (1 in Metabolic Syndrome , 1 in obesity, none in DM)
- Comparing HIIT to moderate intensity training in interventions that lasted at least 4 weeks
- total n=273

HIIT review: *Weston, Br J of Sports Med 2014; 48:1227-1234*

- HIIT group had significantly higher increase in VO2 peak by 9.1%
  - HIIT had 19.4% increase
  - Moderate intensity has 10.3% increase
- Median duration of exercise times was 38 min in HIIT groups vs. 46 min in moderate intensity groups

Table 2 Protocol recommendations for HIIT

Frequency	3×/Week
Duration	40 min
Modality	Treadmill/hill, cycle ergometer. Increasing speed
Intensity	Interval=85–95% PHR Rest=passive–70% PHR
Interval times	4×4 min intervals 3×3 min recovery
Warm-up	10 min at 60% PHR
Cool-down	5 min at 50% PHR

HIIT, homeostasis model assessment-insulin resistance; PHR, peak heart rate

HIIT in type 2 diabetes: Study 1

Little, J Appl Phys 2011

- Effects of 6 HIIT sessions over 2 weeks. n=8
  - Total session time 25 min, 3/week
  - Ten 60-sec sprints at 90% max HR on bike, 60-sec rest
  - 3 min warm-up, 2 min cool-down
- Average 24-hour BG reduced by 13%, 3-hour post prandial glucose AUC reduced by 30% 2 to 3 days after training

In type 2 diabetes: Study 2

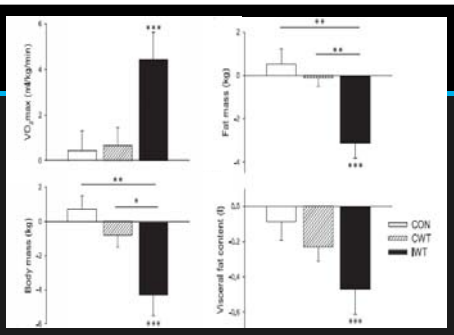
Terada, Diab Res Clin Prac, 2013

- Compared 12 weeks of HIIT versus moderate intensity, n=15
- 5 days/week, 30 min progress to 60 min
- 1 min at 100% VO_2R, 3 min rest vs. 40% VO_2R continuous, same work output
  - Feasible and rated high by participants
  - Equally effective in lowering body fat
  - No significant difference in A1C but baseline A1C was 6.6

Interval training in type 2 diabetes: Study 3

Karstoft, *2013, Diabetes Care*

- Effects of free-living walking interval training, n=32
  - 5 days per week/ 60 min, 4 months
  - Continuous walking at 55% of peak EE
  - Intervals at >70%; 3 minutes fast and 3 minutes slow
  - Control



- Significant differences in VO_2 and body composition
- No difference in fasting glucose or HbA1c
- Did see differences in continuous glucose monitoring (CGM)

Karstoft, *2013, Diabetes Care*

HIIT in Type 2 Diabetes: Study 4

- 23 women aged 35-55 with T2DM.
- Randomized to HIIT vs. no-exercise control for 16 weeks.
- HIIT: Intervals at 90-100% of max.
- Interval duration progressed 30-34 to 52-58 sec, 8-14 bouts, recovery intervals 120-96 sec.

Results: HIIT group had:

- Weight -1.6kg, Waist circ. -4.1 cm.
- HbA1c reduced from 7.0% to 6.1%
- HDL-C increased from 50 to 60 mg/dL

Alvarez C. Int J Sports Med 2016;37:723-729

HIIT in Type 2 Diabetes: Study 5

- Crossover trial, 8 weeks per intervention, with 8-week washout
- HIIT: Three 10-minute sessions/week, mainly low-intensity cycle ergometer, with two 20-sec maximal intensity sprints/session.
- Walking: Five 30-min sessions/week, intensity 40-55% of heart rate reserve.

Results

- Similar decreases in fructosamine (-5%)
- Greater increases in aerobic fitness than walking (7% vs. 1%).
- No significant lipid or body comp changes in either group.

Ruffino JS. Appl Physiol Nutr Metab 2017:42:202-208

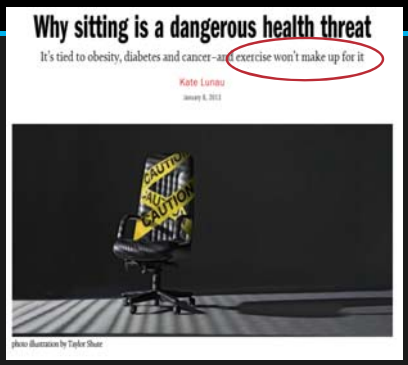
High Intensity Interval Training "HIIT"

- Preliminary evidence of some incremental benefits over continuous moderate-intensity training.
- Longer term effects unknown.
- Safety and acceptability in broader T2D population are unknown.
- Much more research is needed.

How important is it to avoid sedentary behaviour?

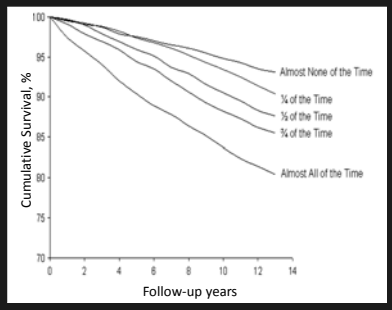
Sedentary Behavior

MACLEAN'S



Canada Fitness Survey of 1981: 7278 men and 9735 women, aged 18–90 yr

Daily Sitting Time



Katzmarzyk, MSSE, 2009 41(5):998-1005

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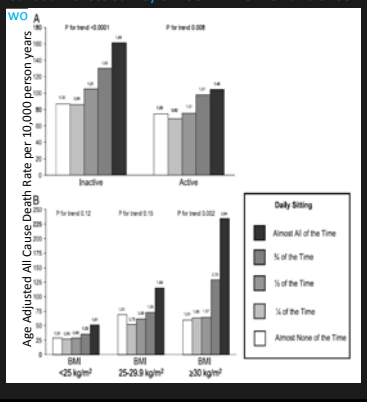


Katzmarzyk, MSSE, 2009 41(5):998-1005

Systematic Review and Meta-analysis

- *Wilmot, Diabetologia (2012) 55:2895–2905*
- 18 studies, (16 prospective cohorts, 2 cross sectional), n= 794,577
- The greatest sedentary time compared to the lowest was associated with:
  - 112% increase in the relative risk of diabetes (RR=2.12)
  - 147% increase in the relative risk of cardiovascular events (RR=2.47)
  - 90% increase in the risk of CVD mortality (HR=1.90)
  - 49% increase in the risk of all-cause mortality (HR=1.49)

Sedentary Behavior

- Many cohort studies document a positive association between sitting and the risk of premature mortality, even after statistically controlling for levels of leisure-time moderate-to-vigorous physical activity.

Sedentary Behavior

- Need to reduce sedentary behavior
- Break up sitting time and screen time
- Data are still young, message is not to now ignore exercise
- …but consider the other $23^{1/2}$ hours in the day

What strategies can reduce exercise-induced hypoglycemia in type 1 diabetes?

Detailed review: Riddell MC et al. Exercise management in type 1 diabetes: a consensus statement. Lancet Diabetes Endocrinol 2017, published online Jan 23, 2017.

Strategies to reduce risk of hypoglycemia from exercise in T1DM

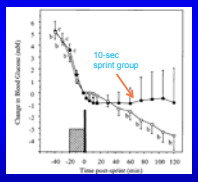
- Adjust insulin.
- Adjust carbohydrate intake.
- Short (10-second) sprints before, during or at the end of exercise.
- Perform resistance exercise before aerobic exercise.

Short sprints

- Interventions involving anaerobic activity (short sprints) have shown some promise for avoidance of hypoglycemia

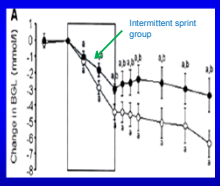
Acute effects of short sprints

10-sec sprint at end of exercise



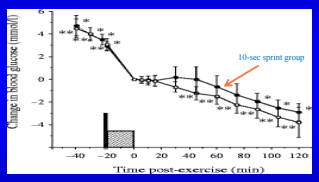
From Bussau, VA et al. Diabetes Care 2006; 29 :501-6.

4-sec sprint every 2 minutes



From Gunll, KJ et al.; Diabetes Care 2005; 28(6):1289-94.

10-second sprint at beginning of exercise



Bussau VA et al, Diabetologia 2007

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- Perform resistance exercise before aerobic exercise.

Jane Yardley, PhD

Design

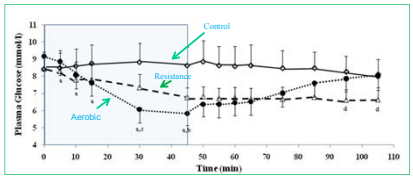
Participants performed five exercise sessions in random order followed by 1 hour of monitored recovery separated by at least 5 days:

1) No exercise (45 minutes seated resting)
2) Aerobic exercise (45 minutes treadmill running at 60% VO_{2peak})
3) Resistance exercise (3 sets of 8 repetitions (8RM))
4) Aerobic then resistance exercise
5) Resistance then aerobic exercise

Participants

N	12 (10 male, 2 female)
Age (yrs)	31.8 ± 15.3
Ht (m)	1.77 ± 0.07
Wt (kg)	79.2 ± 10.4
BMI (kg/m^2)	25.3 ± 3.0
VO_{2peak} (L/kg · min)	51.2 ± 10.8
Hemoglobin A_{1c} (%)	7.13 ± 1.1
Diabetes Duration	12.5 ± 10.0
Insulin delivery	MDI = 5, insulin pump = 7

Aerobic vs. resistance exercise

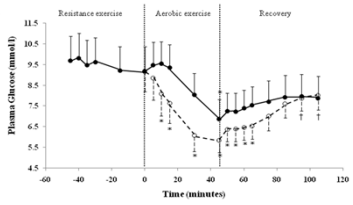


◊ - control
● - aerobic exercise
Δ - resistance exercise

a – significant change from baseline (aerobic)
b - significant change from baseline (resistance)
c – significant difference between aerobic & control
d – significant change throughout recovery (aerobic)

Yardley JE et al. Diabetes Care 2013; 36(3):537-542.

Resistance-then-Aerobic vs. Aerobic only

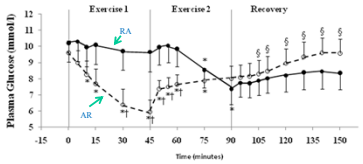


● - resistance then aerobic exercise
○ - aerobic exercise alone

* - significant change from baseline
† - significant change throughout recovery

Yardley JE et al. Can J Diabetes (Suppl.), 2011.

Resistance then Aerobic (RA) vs. Aerobic then Resistance (AR)



● - resistance then aerobic exercise
○ - aerobic then resistance exercise

* - significant change from baseline
† - significant difference between treatments
§ - significant change throughout recovery

Yardley JE et al. Diabetes Care 2012 Apr;35(4):669-75

Summary: acute effects of aerobic and resistance exercise in T1DM

In physically-fit individuals with type 1 diabetes with good glycemic control:

- Resistance exercise on its own was associated with *less acute glucose-lowering* and a *lower need for supplemental glucose* than aerobic exercise on its own
- In sessions combining aerobic and resistance exercise, performing resistance exercise prior to aerobic exercise *decreases the need for carbohydrate intake during exercise* and *may reduce the risk of exercise-induced hypoglycemia* during aerobic exercise.

What if activity is limited by low fitness, obesity and/or arthritis?

- Start with very small amounts of activity (e.g. 5 minutes per day), increase gradually.
- Consider water-based exercise if weight-bearing or arthritis limits physical activity.

Exercise with peripheral neuropathy

- Weight-bearing aerobic exercise is safe, with appropriate foot care.
- Resistance exercise and especially balance training improve balance and stability.
- Exercise training may slow progression of, or partially reverse, peripheral neuropathy.

Streckman F, Sports Med 2014:1289-1304

Strategies to enhance initiation and maintenance of exercise

- Setting specific, realistic, measurable goals.
- Self-monitoring (exercise logs, objective monitoring)
- Motivational interviewing/motivational communication
- Developing strategies to overcome anticipated barriers.

SMART goals in exercise prescription

- **S**pecific
- **M**easurable
- **A**greed-upon, **A**ttainable
- **R**ealistic, Relevant, Rewarding
- **T**ime-based

Back to our five hypothetical patients…

Patient 1: T2DM, otherwise straightforward

"I'm not very active now, but know I should be."

"I have no mobility limitations, and have a reasonable amount of free time and discretionary income."

Patient 2: T2DM, time-challenged

"I know I should be physically active, but I don't have enough time"

Patient 3: T1DM, wants to avoid hypoglycemia

"I have type 1 diabetes. I try to exercise but I am having far too much hypoglycemia."

Patient 4: T2DM, mobility limitation

"My physical activity is limited because of my arthritis".

Patient 5: Peripheral neuropathy

"My peripheral neuropathy is so bad that I have very little sensation in my feet. My new girlfriend wants me to take brisk walks with her, and maybe eventually start jogging. Would this be ok?"

Resources on behavior change

- http://guidelines.diabetes.ca/cdacpg_resources/Motivational-Infographic.pdf
- http://www.motivationalinterviewing.org/
- http://can-change.ca
- http://www.stephenrollnick.com/about-mi.php
- http://www.exerciseismedicine.org/support_page.php/resources/

Questions?

rsigal@ucalgary.ca

Name: _____ Date: _____

q Aerobic Activity

Type: Walk Run Swim Bike Other_____

Frequency (days/week): 2 3 4 5 6 7

Intensity: Light (A Casual Walk) Moderate (A Brisk Walk) Vigorous (Jogging or Running)

Time (minutes/day): 10 20 30 60 60 or more

Steps/day: 2,500 5,000 7,500 10,000 More than 10,000

q Strength Training

- Muscle strengthening should be done at least two days per week
- Exercise should be done to strengthen all major muscle groups: legs, hips, back, chest, abdomen, shoulder, arms
- For each exercise, 8-12 repetitions should be completed
- Examples include bodyweight exercise (e.g. push-ups, lunges), carrying heavy loads, and heavy gardening

Physician Signature:

What do we know about physical activity?

- Regular physical activity can protect your joints, prevent falls and injuries, and reduce your risk of disease, such as type 2 diabetes, high blood pressure, heart attacks, and some cancers.
- Improving your fitness can be as important, or more, than losing weight.
- It is also important to avoid inactivity (*i.e.*, the amount of time you spend sitting) as much as possible. Studies suggest limiting your sedentary time to less than 6-8 hours a day.

What about aerobic activity?

- The *2008 Physical Activity Guidelines for Americans* recommend either 150 minutes per week of moderate activity, 75 minutes of vigorous activity, or a combination of both, for adults.
- Moderate activity is done at a pace where you can carry on a conversation, but cannot "sing". Examples include: *brisk walking, slow biking, water aerobics,* and *general gardening.*
- Vigorous activity is done at a pace where you cannot carry on a conversation and may be out of breath. Examples include: *jogging/running, swimming laps, playing tennis,* and *fast bicycling.*
- Try your best to perform your activity in "bouts" that are at least 10 minutes long (Example – 3 bouts of 10 minutes each day for a total of 30 minutes of activity).

What about strength training?

- The *2008 Physical Activity Guidelines for Americans* also recommend that you do muscle strengthening exercises two times per week to increase bone strength and muscular fitness.
- Adults should perform 8-12 repetitions of activities that work your large muscle groups, such as the legs, hips, abdomen, back, chest, shoulders, and arms.
- These activities do not require going to a gym. You can use resistance bands, do body weight exercises (push-ups, sit-ups, lunges), carry heavy loads, or do heavy gardening or yardwork.

Getting Started

- Doing both aerobic activity (such as walking or jogging) and muscle strengthening is best for your overall health and fitness. If you are just starting out, begin with aerobic exercise.
- If you are not doing 150 minutes a week of aerobic activity, gradually work toward this goal and remember that "some" is better than "none."
- Similar to the aerobic activity, those who are just beginning should gradually increase their strength training slowly and safely over a longer period of time.
- Design your physical activity program so that it fits your schedule.
- Consider working with a local fitness professional to help you safely achieve your goals.
- Most of all have **FUN** and enjoy being physically active!

Cardiorespiratory fitness (CRF) as a vital sign

- VO2 is a strong predictor of mortality
- Every 1 MET increase is associated with a 10-25% reduction in mortality - *Kaminsky, Importance of CRF in the US: policy statement from AHA. Circulation, 2013: 127: 652-62*
- In DM: Each 1-MET increase they found 26% lower risk of death in a model including BMI and other clinical variables

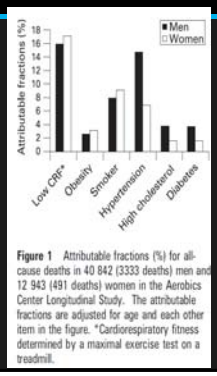


Figure 1 Attributable fractions (%) for all-cause deaths in 40 842 (3333 deaths) men and 12 943 (491 deaths) women in the Aerobics Center Longitudinal Study. The attributable fractions are adjusted for age and each other item in the figure. *Cardiorespiratory fitness determined by a maximal exercise test on a treadmill.

Adapted from Sigal RJ, Ann Intern Med 2007

Sample resistance training program

Mode	Free weights, weight or resistance machines,
Intensity	Moderate to vigorous (50% to 80% of 1-repetition maximum)
Duration	1 to 3 sets of 8 to 15 repetitions per set, including at least 5 to 10 exercises that work the major muscle groups
Frequency	At least 2, but ideally 3, nonconsecutive days per week
Progression	One set of 10 to 15 repetitions to fatigue initially, progressing to 8 to 10 harder repetitions, and finally to 3 sets of 8 to 10 repetitions to fatigue

Sample Weight Exercises	
Seated row	**Seated biceps curl**
Bench press	**Leg curls**
Lat pull down	**Leg extension**
Leg press	**Shoulder press**
Triceps extension	**Abdominal crunches**