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-vigorous 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:


How to prescribe exercise to almost anyone

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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: Amelyn Pharmaceuticals, Merck Pharmaceuticals, Boehringer-Ingelheim, Eli Lilly (Site PI for multicentre trials)
  - In-kind research support: Minimed/Medtronic
  - Consult: None
  - Speakers Honoraria: Sanofi (for a talk in April 2013)
  - Major Stockholder: None
  - Other Financial or Material Support: None

Acknowledgments

Operating support:
- Canadian Institutes of Health Research
- Canadian Diabetes Association
- The Lawson Foundation
- NIH (NHLBI, NIDDK)

Salary support:
- R. Sigal: Health Senior Scholar, Alberta Innovates-Health Solutions (2009-16)

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.


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

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 functional independence 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


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.


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.

**Weight training and risk of heart disease or stroke**

![Graph showing weight lifting and risk of heart disease or stroke](image)

- **Adjustment:** Age only, Multivar, Multivar + other activity
- **Multivariate:** adjusted for EtOH, smoking, family history of MI, nutrient intake

**RCT evidence in type 2 diabetes**

- 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 Proc. 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

**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**

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>3 mo.</th>
<th>6 mo.</th>
<th>Change from 0-6 mo.</th>
<th>Adj mean (95% CI)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Combined</strong></td>
<td>7.46(1.48)</td>
<td>6.99(1.56)</td>
<td>6.56(0.88)</td>
<td>-0.90(-1.15 to -0.64)</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td><strong>Aerobic</strong></td>
<td>7.41(1.50)</td>
<td>7.00(1.59)</td>
<td>6.98(1.38)</td>
<td>-0.43(1.19 to -0.67)</td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td><strong>Resistance</strong></td>
<td>7.48(1.47)</td>
<td>7.32(1.57)</td>
<td>7.18(1.52)</td>
<td>-0.30(1.56 to -0.65)</td>
<td>0.018</td>
<td></td>
</tr>
<tr>
<td><strong>Control</strong></td>
<td>7.44(1.38)</td>
<td>7.33(1.49)</td>
<td>7.51(1.47)</td>
<td>-0.16(-0.32 to 0.00)</td>
<td>0.37</td>
<td></td>
</tr>
</tbody>
</table>
### Results: A1c (%)—Baseline >7.5%

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>3 mo.</th>
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<th>Adj mean (95% CI)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combined</td>
<td>8.44 (1.04)</td>
<td>7.64 (1.32)</td>
<td>7.02 (1.35)</td>
<td>-0.42 (-0.63 to -0.21)</td>
<td>7.02 (1.35)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Aerobic</td>
<td>8.31 (1.16)</td>
<td>7.51 (1.49)</td>
<td>7.47 (1.35)</td>
<td>-0.84 (-1.36 to -0.32)</td>
<td>7.47 (1.35)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Resistance</td>
<td>8.29 (1.14)</td>
<td>8.06 (1.42)</td>
<td>7.80 (1.42)</td>
<td>-0.49 (-0.97 to 0.00)</td>
<td>7.80 (1.42)</td>
<td>0.013</td>
</tr>
<tr>
<td>Control</td>
<td>8.30 (1.03)</td>
<td>8.06 (1.38)</td>
<td>8.28 (1.39)</td>
<td>-0.22 (-0.40 to 0.36)</td>
<td>8.28 (1.39)</td>
<td>0.001</td>
</tr>
</tbody>
</table>

### Results: A1c (%)—Baseline <7.5%

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>3 mo.</th>
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<th>Change from 0-6 mo.</th>
<th>Adj mean (95% CI)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combined</td>
<td>6.93 (0.41)</td>
<td>6.76 (0.79)</td>
<td>6.48 (0.84)</td>
<td>-0.46 (-0.73 to -0.18)</td>
<td>6.48 (0.84)</td>
<td>0.002</td>
</tr>
<tr>
<td>Aerobic</td>
<td>7.05 (0.48)</td>
<td>6.96 (0.79)</td>
<td>6.80 (0.79)</td>
<td>-0.19 (-0.38 to 0.00)</td>
<td>6.80 (0.79)</td>
<td>0.19</td>
</tr>
<tr>
<td>Resistance</td>
<td>6.95 (0.37)</td>
<td>6.93 (0.76)</td>
<td>6.87 (0.82)</td>
<td>-0.08 (-0.38 to +0.22)</td>
<td>6.87 (0.82)</td>
<td>0.19</td>
</tr>
<tr>
<td>Control</td>
<td>6.85 (0.33)</td>
<td>6.88 (0.79)</td>
<td>7.12 (0.81)</td>
<td>+0.27 (+0.11 to +0.46)</td>
<td>7.12 (0.81)</td>
<td>0.24</td>
</tr>
</tbody>
</table>

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**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


Thanks to Tim Church for HART-D slides

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**Changes in Diabetes Medications**

![Changes in Diabetes Medications](chart.png)
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.
- Four year results: Arch Intern Med 2010;170:1566-1575.
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

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.”

“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

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).

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
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)

Descriptives

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>57.3 (6.4)</td>
</tr>
<tr>
<td>Caucasian</td>
<td>65%</td>
</tr>
<tr>
<td>HRT use</td>
<td>49%</td>
</tr>
<tr>
<td>SBP</td>
<td>139.0 (12.8) mmHg</td>
</tr>
<tr>
<td>DBP</td>
<td>80.4 (7.9)  mmHg</td>
</tr>
<tr>
<td>VO2 Max Absolute</td>
<td>1.3 (0.24) l/min</td>
</tr>
<tr>
<td>VO2 Max Relative</td>
<td>15.6 (2.9) ml/kg/min</td>
</tr>
<tr>
<td>BMI</td>
<td>31.7 (3.8) kg/m2</td>
</tr>
<tr>
<td>Waist Circ</td>
<td>101.3 (11.9) cm</td>
</tr>
<tr>
<td>LDL</td>
<td>119.0 (26.7) mg/dl</td>
</tr>
<tr>
<td>HDL</td>
<td>57.5 (14.4) mg/dl</td>
</tr>
<tr>
<td>Triglycerides</td>
<td>131.6 (64.9) mg/dl</td>
</tr>
<tr>
<td>Glucose</td>
<td>95.1 (8.8) mg/dl</td>
</tr>
<tr>
<td>CRP</td>
<td>5.6 (5.5) mg/l</td>
</tr>
</tbody>
</table>
91% complete study

Adherence Across Exercise Groups

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

<table>
<thead>
<tr>
<th>Exercise Groups</th>
<th>4 kcal/kg</th>
<th>8 kcal/kg</th>
<th>12 kcal/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residual energy expenditure</td>
<td>335 (±9)</td>
<td>681 (±12)</td>
<td>1006 (±13)</td>
</tr>
<tr>
<td>Time exercise, min/week</td>
<td>72.2 (12.2)</td>
<td>135.0 (19.0)</td>
<td>161.7 (20.2)</td>
</tr>
<tr>
<td>Average METs per session</td>
<td>3.8 (0.4)</td>
<td>3.8 (0.3)</td>
<td>3.9 (0.4)</td>
</tr>
<tr>
<td>Cycle ergometer</td>
<td>3.1 (0.6)</td>
<td>3.3 (0.6)</td>
<td>3.5 (0.8)</td>
</tr>
<tr>
<td>Treadmill</td>
<td>2.6 (0.9)</td>
<td>2.8 (0.4)</td>
<td>3.1 (0.8)</td>
</tr>
<tr>
<td>Percentage adherence, %</td>
<td>94.6 (15.6)</td>
<td>89.0 (23.0)</td>
<td>93.3 (16.1)</td>
</tr>
<tr>
<td>All completers</td>
<td>90.0 (8.6)</td>
<td>97.0 (7.7)</td>
<td>97.4 (11.0)</td>
</tr>
</tbody>
</table>

Explanations: METs, metabolic equivalents (1 MET = 3.5 mL of O2 uptake/kg per minute).
All data are presented as means ± SD.
Excerpt for all participants and based on baseline weight.

Change in Fitness

DREW & WHI Data Combined: Risks From WHI for Age Range 50-59y

DREW Group: 4KKW 8 KK12KKW
MET—Hours/week: 3.7 7.5 11.2

RR of CVD

RR of CVD

<table>
<thead>
<tr>
<th>Study Groups</th>
<th>4KKW</th>
<th>8KKW</th>
<th>12KKW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median:</td>
<td>3.8</td>
<td>7.5</td>
<td>16.7</td>
</tr>
<tr>
<td>Range:</td>
<td>1.5</td>
<td>2.6</td>
<td>5.1</td>
</tr>
</tbody>
</table>
Quality of Life Measures

Change in Physical Health

<table>
<thead>
<tr>
<th>Study Groups</th>
<th>Control</th>
<th>72 minutes</th>
<th>136 minutes</th>
<th>192 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPH</td>
<td>3.65</td>
<td>7.35</td>
<td>8.56</td>
<td>10.35</td>
</tr>
</tbody>
</table>

Change in Mental Health

<table>
<thead>
<tr>
<th>Study Groups</th>
<th>Control</th>
<th>72 minutes</th>
<th>136 minutes</th>
<th>192 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMSH</td>
<td>3.32</td>
<td>8.41</td>
<td>8.55</td>
<td>11.86</td>
</tr>
</tbody>
</table>

Change in Energy

<table>
<thead>
<tr>
<th>Study Groups</th>
<th>Control</th>
<th>72 minutes</th>
<th>136 minutes</th>
<th>192 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>5.21</td>
<td>12.25</td>
<td>11.58</td>
<td>14.42</td>
</tr>
</tbody>
</table>

Sleep Disturbances subscale

<table>
<thead>
<tr>
<th>Study Groups</th>
<th>Control</th>
<th>72 min/wk</th>
<th>136 min/wk</th>
<th>192 min/wk</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOS Sleep Score</td>
<td>Change in MOS Sleep Score</td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

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.


Weight training and risk of heart disease or stroke

Aerobic vs. resistance exercise and HbA1c

Dose-response is not the same

DARE trial Results: A1c (%) changes over time

HbA1c (%) - compliance >90%

<table>
<thead>
<tr>
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<th>3 mo.</th>
<th>6 mo.</th>
<th>Change from 0-6 mo.</th>
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</thead>
<tbody>
<tr>
<td>Combined n=64</td>
<td>7.46</td>
<td>6.99</td>
<td>6.56</td>
<td>-0.90 (-1.15 to -0.64)</td>
</tr>
<tr>
<td>(40M,24F)</td>
<td>(1.48)</td>
<td>(1.56)</td>
<td>(0.88)</td>
<td></td>
</tr>
<tr>
<td>Aerobic n=60</td>
<td>7.41</td>
<td>7.00</td>
<td>6.98</td>
<td>-0.43 (-0.64 to -0.21)</td>
</tr>
<tr>
<td>(39M,21F)</td>
<td>(1.50)</td>
<td>(1.36)</td>
<td>(0.80)</td>
<td></td>
</tr>
<tr>
<td>Resistance n=64</td>
<td>7.48</td>
<td>7.35</td>
<td>7.18</td>
<td>-0.30 (-0.56 to -0.05)</td>
</tr>
<tr>
<td>(40M,24F)</td>
<td>(1.47)</td>
<td>(1.57)</td>
<td>(1.52)</td>
<td></td>
</tr>
<tr>
<td>Control n=63</td>
<td>7.44</td>
<td>7.33</td>
<td>7.51</td>
<td>+0.07 (+0.18 to +0.32)</td>
</tr>
<tr>
<td>(41M,22F)</td>
<td>(1.38)</td>
<td>(1.49)</td>
<td>(1.47)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>3 months</th>
<th>6 months</th>
<th>Change Baseline to 6M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerobic n=60</td>
<td>7.51</td>
<td>7.14</td>
<td>6.92</td>
<td>-0.62 (1.01) -7.5% (12.3)</td>
</tr>
<tr>
<td>(40M,24F)</td>
<td>(0.64)</td>
<td>(0.71)</td>
<td>(0.76)</td>
<td></td>
</tr>
<tr>
<td>Resistance n=26</td>
<td>7.36</td>
<td>7.12</td>
<td>7.12</td>
<td>-0.24 (0.79) -3.0% (13.9)</td>
</tr>
<tr>
<td>(17M,9F)</td>
<td>(0.70)</td>
<td>(0.65)</td>
<td>(0.70)</td>
<td></td>
</tr>
<tr>
<td>Combined n=26</td>
<td>7.72</td>
<td>7.03</td>
<td>6.63</td>
<td>-1.09 (1.2) -13.9% (13.7)</td>
</tr>
<tr>
<td>(17M,9F)</td>
<td>(0.01)</td>
<td>(0.71)</td>
<td>(0.85)</td>
<td></td>
</tr>
<tr>
<td>Control n=63</td>
<td>7.66</td>
<td>7.55</td>
<td>7.72</td>
<td>+0.06 (1.62) +1.1% (13.7)</td>
</tr>
<tr>
<td>(41M,22F)</td>
<td>(0.89)</td>
<td>(1.1)</td>
<td>(1.22)</td>
<td></td>
</tr>
</tbody>
</table>
A1C (%)-compliance 75-90%

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>3 months</th>
<th>6 months</th>
<th>Change Baseline to 6M absolute</th>
<th>relative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerobic</td>
<td>7.55 (0.69)</td>
<td>7.06 (0.94)</td>
<td>7.16 (0.95)</td>
<td>-0.38 (1.03)</td>
<td>-4.2% (10.7)</td>
</tr>
<tr>
<td>Resistance</td>
<td>7.64 (0.83)</td>
<td>7.62 (1.02)</td>
<td>7.62 (1.05)</td>
<td>-0.22 (0.90)</td>
<td>-2.9% (11.2)</td>
</tr>
<tr>
<td>Combined</td>
<td>7.74 (0.94)</td>
<td>7.17 (1.22)</td>
<td>6.85 (0.89)</td>
<td>-0.89 (0.69)</td>
<td>-11.2% (8.2)</td>
</tr>
<tr>
<td>Control</td>
<td>7.66 (0.89)</td>
<td>7.55 (1.1)</td>
<td>7.72 (1.22)</td>
<td>+0.06 (1.02)</td>
<td>+1.1%</td>
</tr>
</tbody>
</table>

Results: A1c (%)-compliance <75%

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>3 months</th>
<th>6 months</th>
<th>Change Baseline to 6M absolute</th>
<th>relative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerobic</td>
<td>7.95 (0.86)</td>
<td>7.52 (1.06)</td>
<td>7.55 (1.08)</td>
<td>-0.43 (1.14)</td>
<td>-4.9% (14.8)</td>
</tr>
<tr>
<td>Resistance</td>
<td>7.74 (0.83)</td>
<td>7.66 (1.13)</td>
<td>7.67 (1.15)</td>
<td>-0.46 (0.76)</td>
<td>-5.7% (9.6)</td>
</tr>
<tr>
<td>Combined</td>
<td>7.53 (0.73)</td>
<td>7.57 (0.80)</td>
<td>7.14 (0.89)</td>
<td>-0.39 (0.96)</td>
<td>-4.7% (11.4)</td>
</tr>
<tr>
<td>Control</td>
<td>7.66 (0.89)</td>
<td>7.55 (1.1)</td>
<td>7.72 (1.22)</td>
<td>+0.06 (1.02)</td>
<td>+1.1%</td>
</tr>
</tbody>
</table>

---

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

  - 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 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

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


- Compared 12 weeks of HIIT versus moderate intensity, n=15
  - 5 days/week, 30 min progress to 60 min
  - 1 min at 100% VO2R, 3 min rest vs. 40% VO2R 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 VO2 and body composition
  - No difference in fasting glucose or HbA1c
  - Did see differences in continuous glucose monitoring (CGM)
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.


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.


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

Why sitting is a dangerous health threat: It’s linked to obesity, diabetes and cancer - so please sit less.
Systematic Review and Meta-analysis

- 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 23½ hours in the day

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

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-second sprint at beginning of exercise

From Bussau VA et al, Diabetologia 2007

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.

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$_{2\text{peak}}$)
3. Resistance exercise (3 sets of 8 repetitions (8RM))
4. Aerobic then resistance exercise
5. Resistance then aerobic exercise

**Participants**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>12 (10 male, 2 female)</td>
</tr>
<tr>
<td>Age (yrs)</td>
<td>31.8 ± 15.3</td>
</tr>
<tr>
<td>Ht (m)</td>
<td>1.77 ± 0.07</td>
</tr>
<tr>
<td>Wt (kg)</td>
<td>79.2 ± 10.4</td>
</tr>
<tr>
<td>BMI (kg/m$^2$)</td>
<td>25.3 ± 3.0</td>
</tr>
<tr>
<td>VO$_{2\text{peak}}$ (L/kg · min)</td>
<td>51.2 ± 10.8</td>
</tr>
<tr>
<td>Hemoglobin A$_1c$ (%)</td>
<td>7.13 ± 1.1</td>
</tr>
<tr>
<td>Diabetes Duration</td>
<td>12.5 ± 10.0</td>
</tr>
<tr>
<td>Insulin delivery</td>
<td>MDI = 5, insulin pump = 7</td>
</tr>
</tbody>
</table>

**Aerobic vs. resistance exercise**


<table>
<thead>
<tr>
<th></th>
<th>aerobic exercise</th>
<th>resistance exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>significant change from baseline (aerobic)</td>
<td>significant change from baseline (resistance)</td>
</tr>
<tr>
<td>11</td>
<td>significant difference between aerobic and control</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>significant change throughout recovery (aerobic)</td>
<td></td>
</tr>
</tbody>
</table>

**Resistance-then-Aerobic vs. Aerobic only**


<table>
<thead>
<tr>
<th></th>
<th>resistance then aerobic exercise</th>
<th>aerobic exercise alone</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>* significant change from baseline</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>† significant change throughout recovery</td>
<td></td>
</tr>
</tbody>
</table>

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

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

<table>
<thead>
<tr>
<th></th>
<th>resistance then aerobic exercise</th>
<th>aerobic then resistance exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>* significant change from baseline</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>‡ significant difference between treatments</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>§ significant change throughout recovery</td>
<td></td>
</tr>
</tbody>
</table>

**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.

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

- Specific
- Measurable
- Agreed-upon, Attainable
- Realistic, Relevant, Rewarding
- Time-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.”

Streckman F, Sports Med 2014:1289-1304
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://www.motivationalinterviewing.org/
- http://can-change.ca
- http://www.exerciseismedicine.org/support-page.php/resources

Questions?
rsigal@ucalgary.ca
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

Sample resistance training program

Mode: Free weights, weight or resistance machines, 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
- Lat pull down
- Leg extension
- Leg press
- Shoulder press
- Triceps extension
- Abdominal crunches

Adapted from Sigal RL. Ann Intern Med 2007