Exercise and Type 2 Diabetes

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Characteristics of Type 1 & Type 2 Diabetes Mellitus

<table>
<thead>
<tr>
<th>Type 1</th>
<th>Type 2</th>
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</thead>
<tbody>
<tr>
<td>&lt; 20 yrs</td>
<td>Age at onset</td>
</tr>
<tr>
<td>5-10%</td>
<td>Percent of diabetes</td>
</tr>
<tr>
<td>Uncommon</td>
<td>Family History</td>
</tr>
<tr>
<td>Required</td>
<td>Insulin use</td>
</tr>
<tr>
<td>Normal</td>
<td>Obese/Overweight</td>
</tr>
<tr>
<td>Immune dysfunction</td>
<td>Pathological factor(s)</td>
</tr>
<tr>
<td></td>
<td>Age; weight; race; family history</td>
</tr>
<tr>
<td></td>
<td>&gt; 30 yrs*</td>
</tr>
<tr>
<td></td>
<td>90-95%</td>
</tr>
<tr>
<td></td>
<td>Common</td>
</tr>
<tr>
<td></td>
<td>Maybe</td>
</tr>
<tr>
<td></td>
<td>80-90%</td>
</tr>
</tbody>
</table>
Rate of New Cases of Type 1 & Type 2 Diabetes among Youth < 20 yrs

Estimated Growth in Type 2 Diabetes: US Population From 2000-2050

Age-adjusted % of U.S. Adults Who Were Obese or Who Had Diagnosed Diabetes

Obesity (BMI ≥30 kg/m²)

1994

2000

2009

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

Diabetes

1994

2000

2009

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


Diabetes Prevalence: Age and Ethnicity

20-39  40-49  50-59  60-74  75+

Percentage (%)

Portland 2011 - T2DM
**Natural History of Type 2 Diabetes**

- Years from diagnosis
  - Pre-diabetes
  - Type 2 diabetes

**Stages of Type 2 Diabetes**

- Beta-Cell Function (% β)
- Years From Diagnosis
  - MonoTherapy
  - Combination Oral Therapy
  - Insulin

Based on data of UKPDS 16: Diabetes. 1995.
**Cardiometabolic Risk - Graphic**

- Age
- Genetics
- Insulin Resistance Syndrome
- Lipids
- BP
- Glucose
- Overweight / Obesity
- Abnormal Lipid Metabolism
  - LDL
  - ApoB
  - HDL
  - Triglyceride
- Global Diabetes / CVD Risk
- Inflammation
- Hypercoagulation
- Hypertension
- Smoking
- Unhealthy Eating
- Physical Inactivity
- Age, Race, Gender, Family History
- Insulin Resistance Syndrome

**Proportion of Patients with Cardiovascular Disease Increases with Duration of Diabetes**

- Years after DM Diagnosis:
  - ≤ 2: 15%
  - 3-5: 21%
  - 6-9: 24%
  - 10-14: 29%
  - 15+: 48%

*Harris, S. et al.; Type 2 Diabetes and Associated Complications in Primary Care in Canada: The Impact of Duration of Disease on Morbidity Load. CDA 2003.*
Management of Diabetes Mellitus: Therapeutic Steps in Management

- Medical management
- Use of medications to manage glucose
  - oral agents and/or
  - insulin
- Frequent monitoring of blood glucose
- Proper diet and exercise
Mechanisms of Action of Pharmacologic Agents for Diabetes

Summary of Pharmacologic Incretin Actions on Different Target Tissues

Drucker DJ, Cell Metab. 2006;3:153-165.
Exercise + Lifestyle Benefits

- ↑ insulin sensitivity
- ↓ of diabetes medications
- ↑ glucose control for type 2
- Predictor of successful weight management
- Aids in managing other Cardiometabolic risks
  - Hypertension
  - Dyslipidemia
  - Obesity, Body weight/fat and morphology
- Psychoemotional benefits
  - Anxiety, Depression, Self-esteem

Diabetes Prevention Program

[DPP]: Preventive Strategies?

- Clinical trials examined prevention of type 2 diabetes
- LIFESTYLE was very effective
  - Physical activity ≥ 150 mins/wk
  - MNT for diabetes
  - Strategies for success
- Is the DPP an effective ‘model’ for secondary prevention?
Diabetes Incidence Rates by Ethnicity

- **Caucasian** (n=1768)
- **African American** (n=645)
- **Hispanic** (n=508)
- **American Indian** (n=171)
- **Asian** (n=142)

Diabetes Incidence Rates by BMI

- **24 ≤ 30** (n=1045)
- **30 ≤ 35** (n=995)
- **≥ 35** (n=1194)
**DPP: Weight Loss and Physical Activity**

- **Placebo**
- **Metformin**
- **Lifestyle**

- Weight Change (kg)
- MET-hours/week

- Placebo: [Graph showing weight change and MET-hours/week]
- Metformin: [Graph showing weight change and MET-hours/week]
- Lifestyle: [Graph showing weight change and MET-hours/week]

**Type 2 Diabetes: Exercise Program with NO Complications**

**Aerobic**
- **Frequency**: 5-7 d/wk
- **Intensity**: 40-60% HR Reserve, RPE (4-6 on 10)
- **Time**: expend $\geq$ 200 - 300 Kcals/d, Kcals/wk $> 1,500 - 2,000$, At least 150 mins/wk

**Resistance**
- **Frequency**: $\geq$ 3 d/wk
- **Intensity**: moderate
- **Repetitions**: 8-10 per exercise
- **Sets**: $\geq$ 3 sets per exercise
- **Type**: major muscle groups: 8-10 exercises

*The DPP Research Group, NEJM 346:393-403, 2002*
Association Between Insulin Sensitivity and Physical Exercise: The IRAS Study

**Insulin sensitivity**

![Graph showing insulin sensitivity vs exercise frequency]

**Fasting insulin**

![Graph showing fasting insulin vs exercise frequency]


Aerobic Exercise Improves Insulin Sensitivity

**Glucose Clamps**

![Graph showing glucose uptake and production]

Glucose uptake: Pretraining (orange) vs Post-training (green)

Glucose production: Pretraining (red) vs Post-training (green) with an asterisk indicating significant difference.

**Effect of Physical Activity on Glucose Control**

- HbA1c % is lowered
- Clinical implications: risk for complications
  - UKPDS - 0.6% ↓ in HbA1c lowered risk reduction by 32% for complications and 42% for diabetes-related death

**Physical Activity Alone Results in Minimal Weight Loss**

*P<0.05 vs control group

Duration of each study ranged from 4 to 12 months. Subjects were obese, IGT, and T2DM
Physical Activity Usually Does Not Increase Short-Term Diet-Induced Weight Loss

*P<0.05 vs diet-only group. Each study ranged from 4 to 6 months.

Fatness, Fitness and Cardiovascular Disease Mortality

Physical Activity Helps Preserve Fat-Free Mass During Weight Loss

<table>
<thead>
<tr>
<th>Diet Only</th>
<th>Diet Plus Physical Activity</th>
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<tbody>
<tr>
<td>Men</td>
<td>Women</td>
</tr>
<tr>
<td>30%</td>
<td>20%</td>
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</tbody>
</table>

*P < 0.05


Relationship Between Physical Activity and Maintenance of Weight Loss

<table>
<thead>
<tr>
<th>Subjects Exercising (%)</th>
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</thead>
<tbody>
<tr>
<td>Not Maintained</td>
</tr>
<tr>
<td>Maintained</td>
</tr>
</tbody>
</table>

P < 0.001

Morphologic Changes with Activity: Composition & Health Risk Issues

Improvements of lipoprotein-lipid profile and insulin/glucose metabolism

Mobilization of visceral AT without significant changes in adiposity

Other physical and metabolic improvements

Mobilization of visceral AT and significant weight loss

Sedentary Viscerally obese
Physically active Viscerally obese
Physically active Nonobese

Relationship Between Change in Weight and Blood Pressure: Trials of Hypertension Prevention

Change in Weight (kg)
Change in Blood Pressure (mm Hg)

Quintile of Weight Change

U.S. Adult Participation in Regular Strengthening Exercises

Resistance Exercise: Clinical Trial in Type 2 Diabetes

Schoenborn & Barnes, National Center for Health Statistics, 2002

Dunstan et al., Diab Care, 25: 1729-1736, 2002
Resistance Training and Glycemic Control in Type 2 Diabetes?

Results yielded:

- ~1% reduction in HbA$_{1c}$
- Clinical implications
- Decrease in meds
- Favorable blood pressure and morphologic changes
Key Points for Medical & Allied Health Practitioners – “TOOL BOX”

• **Pre-exercise:**
  • Ensure Client’s file includes *ABC*s:
    • A1C - glucose control
    • Blood pressure
    • Presence/status of Complications
  • Encourage *intensive* management of diabetes
  • Aid in ‘*planning*’ for each day’s activity, exercise, or recreation
  • Educate client on:
    • Frequent Glucose √’s
    • Self-Monitoring of Blood Glucose
    • Balanced nutrition
    • RD?

Client Assessment – “TOOL BOX”

✔ Evaluate client, especially for CAD
✔ Routine screening of asymptomatic diabetic patients is not recommended
✔ Assess for:
  ✔ Diabetes Control
  ✔ Hypertension Control
  ✔ Diabetes complications - awareness
  ✔ Age
  ✔ Prior physical activity habits
  ✔ Functional ability or limitations
Safe Exercise: 
Routine Blood Glucose Checks - “TOOL BOX”

- **ALWAYS check pre-exercise glucose**
  - IF glucose 100 - 250 mg/dl
    - okay to exercise
  - IF glucose >250 mg/dl
    - Use caution for exercise
  - IF glucose < 100 mg/dl - give 15-30 g CHO
    - Re-check glucose to ensure BG > 100 mg/dl

- **ALWAYS check post-exercise glucose**

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Strategies for An Active Lifestyle

- Walking more [steps] each day for type 2 diabetes
  - “Steps” are linked with:
    - ↑ glucose metabolism
    - ↑ aerobic fitness
    - ↑ weight management
- Use of PEDOMETER
**Practical Recommendations for Persons with Diabetes Mellitus - “TOOL BOX”**

- **Self-Blood Glucose Monitoring**
  - Before and after each exercise session.

- **Keep a daily log:**
  - Glucose values
  - Medication
  - Time, effort, and distance of exercise session.

- **Plan for an exercise session:**
  - When? How much activity?
  - If needed, carry extra carbohydrate feedings

- **Exercise with partner:**
  - until glucose response is known.

- **Wear a diabetes I.D.:**
  - Never leave home without it.

- **Wear good shoes:**
  - Proper-fitting and comfortable footwear can minimize foot irritations, and limit orthopedic injury to the foot and lower leg.

- **Practice good hygiene**

- **Modify caloric intake**

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**Common Pathways in Diabetes Complications**

Diabetes complications (eye, kidney, nerve, blood vessels) arise from a number of triggers perturbing a limited number of metabolic pathway(s) (Brownlee, 2001).

- **Glucose**
- **Polyol Pathway**
- **Hexosamine Pathway**
- **Oxidative Stress**
- **AGE Formation**
- **Cellular Dysfunction**
- **ROS**
- **Cell Damage**
- **Vascular Damage**
- **Nephropathy**
- **Retinopathy**
- **Peripheral & Autonomic Neuropathy**
Exercising With Complications:
Standards of Care of Practice [ADA, 2011] - "TOOL BOX"

**Cardiovascular Disease**
- If diagnosed with CVD, THEN... client likely needs stress test.
- No CVD: client may need stress test if moderate-to-vigorous intensity.
- No CVD: Low-to-moderate intensity may be OK.
  + Physician judgement.

**Peripheral Arterial Disease**
- Leg pain linked with PAD may limit weight-bearing activity.
- Oxygen intermitent claudication with exercise.
- Walking - most effective for claudication.
  - Interval training for 3-5 mins exercise followed by brief rest to ease symptoms.
  - May require cardiac rehab for initial exercise.

Exercising With Complications:
Standards of Care of Practice [ADA, 2011] - "TOOL BOX"

**Retinopathy**
- May need dilated exam.
- Proliferative Retinopathy [PDR] - no vigorous or static exercise.
  + Resistance training.
- Lower intensity activities.
  + Cardio & resistance activities.

**Nephropathy**
- Exercise may ↑ urinary protein.
- No evidence that vigorous exercise ↑ rate of progression.
- No likely exercise restrictions specific to kidney disease!
**Exercising With Complications:**

**Standards of Care of Practice** [ADA, 2011] - "TOOL BOX"

- **Peripheral Neuropathy**
  - Motor & Sensory nerves
  - Pain sensation & loss of sensation in extremities
  - Risk of infection/injury
  - Limit weight-bearing exercise
  - Encourage alternate activities:
    - Swim, bike, water aerobics

- **Autonomic Neuropathy**
  - Affects HR
  - Risk of exercise-induced injury or adverse event
  - Thermoregulation
  - Gastric emptying
  - Papillary function

- **Risk of CVD in diabetes**
- **Cardiac assessment**

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**Cardiometabolic Risk - Graphic**

- Abnormal Lipid Metabolism
  - LDL ➠
  - ApoB ➠
  - HDL ➠
  - Trigly. ➠

- Global Diabetes / CVD Risk
- Overweight / Obesity

- Insulin Resistance Syndrome
- Genetics
- Age, Race, Gender, Family History

- Inflammation
- Hypercoagulation

- Hypertension
- Unhealthy Eating
- Smoking
- Physical Inactivity
An Active Lifestyle BEGINS with YOUR 1st Step

Exercise & Diabetes: Redefining Exercise Programs

- Current knowledge of type 2 diabetes + exercise
- Challenges facing exercise program development for heterogeneous type 2 diabetes
Remember to Empower Your Client

We don’t plan to fail,
but we do fail to plan

Meaning:

Your Client  Must have a PLAN of Action