Exercise: System-Wide Effects

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Disclosures

• Scientific Advisory Board:
  – Weight Watchers International

• Research Grants Awarded to the University of Pittsburgh
  – National Institutes of Health
  – Weight Watchers International
  – HumanScale
Pathway for Physical Activity (Exercise) to influence Health

Physical Activity

Health-Related Outcomes
Pathway for Physical Activity (Exercise) to influence Health

Physical Activity → Fitness → Health-Related Outcomes
Pathway for Physical Activity (Exercise) to influence Health

Physical Activity → Fitness → Health-Related Outcomes
Physical Activity

Fitness

Body Weight and Adiposity

Health-Related Outcomes

Pathway for Physical Activity (Exercise) to influence Health
Pathway for Physical Activity (Exercise) to influence Health

- Physical Activity
- Fitness
- Body Weight and Adiposity
- Health-Related Outcomes
Pathway for Physical Activity (Exercise) to influence Health

Physical Activity → Fitness

Health-Related Outcomes

Diet

Body Weight and Adiposity
Pathway for Physical Activity (Exercise) to influence Health

Physical Activity ➔ Fitness ➔ Health-Related Outcomes

Diet ➔ Body Weight and Adiposity ➔ Health-Related Outcomes
Pathway for Physical Activity (Exercise) to influence Health

- Physical Activity
- Fitness
- Diet
- Body Weight and Adiposity
- Health-Related Outcomes
Pathway for Physical Activity (Exercise) to influence Health

Physical Activity → Fitness

Fitness → Health-Related Outcomes

Physical Activity → Diet

Diet → Health-Related Outcomes

Physical Activity → Body Weight and Adiposity

Body Weight and Adiposity → Health-Related Outcomes
Pathway for Physical Activity (Exercise) to influence Health

- Physical Activity
- Fitness
- Behavior
- Diet
- Body Weight and Adiposity
- Health-Related Outcomes
Pathway for Physical Activity (Exercise) to influence Health

- **Behavior**
- **Physical Activity**
- **Fitness**
- **Health-Related Outcomes**
- **Diet**
- **Body Weight and Adiposity**

The diagram illustrates the pathways through which physical activity (exercise) influences health, including the interconnections with behavior, diet, fitness, and health-related outcomes.
Key Health Areas of Interest

• Obesity
• Cardiovascular Disease
• Type 2 Diabetes Mellitus
Key Health Areas of Interest

Obesity
Weight Loss Achieved in Behavioral Intervention Programs

Jakicic - 2008
Jakicic - 2014
Jakicic - 2012

Weight Loss Achieved in Behavioral Intervention Programs

Percent Weight Loss

Months

Jakicic - 2008
Jakicic - 2008
Jakicic - 2008
Jakicic - 2014
Jakicic - 2014
Jakicic - 2012
Jakicic - 2012
Weight Loss Achieved in Behavioral Intervention Programs

[Graph showing weight loss over months for different programs, labeled with different years and colors for each study.]
What is the Impact of Physical Activity plus Prescribed Diet in the Management of Body Weight?
Effect in Class II and III Obesity

Goodpaster et al. JAMA 2010
Effect in Class II and III Obesity

2.4 kg (22%) difference in weight loss between groups

Goodpaster et al. JAMA 2010
What is the Long-Term Impact of Physical Activity in the Management of Body Weight?
Dose of Exercise and Long-Term Weight Loss

Jakicic, et al. JAMA. 1999

110 min/wk

175 min/wk

280 min/wk

Jakicic, et al. JAMA. 1999
Physical activity (0, 6, and 24 months) for categories of 24-month weight loss (N = 170).

*1500 kcal/wk or 275 min/wk above baseline

What is the Long-Term Impact of Physical Activity in the Management of Body Weight?

OBJECTIVELY MEASURED PHYSICAL ACTIVITY
<table>
<thead>
<tr>
<th>Subjects Grouped based on Weight Loss Achieved and Maintained</th>
<th>&gt;10% Weight Loss at 6 Months</th>
<th>&gt;10% Weight Loss at 18 Months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Loss (n=107, 41%)</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Late-Loss (n=19, 7%)</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Non-Maintain (n=45, 17%)</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Maintain (n=87, 34%)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Jakicic et al. *Obesity*. 2014
% Change in Body Weight by Group

P-Values
- Weight Change Group: <0.0001
- Time: <0.0001
- Weight Change Group X Time: <0.0001

Jakicic et al. *Obesity*. 2014
Change in Moderate-to-Vigorous Intensity Physical Activity (bouts >10 minute in duration) by Weight Loss Pattern

P-Values
Weight Change Group: <0.0001
Time: <0.0001
Weight Change Group X Time: <0.0001

Jakicic et al. *Obesity*. 2014
Change in Light Intensity Physical Activity by Weight Loss Pattern

P-Values
Weight Change Group: 0.0002
Time: 0.0326
Weight Change Group X Time: 0.0075

Jakicic et al. *Obesity*. 2014
Weight Variability in Response to Physical Activity
Mid-West Exercise Study
Responders and Non-responders (Women)

Donnelly et al.
Difference in Individual Energy Intake Following Rest and Exercise

Consume more following Rest compared to Exercise

Consume more following Exercise compared to Rest

Adapted from Unick et al. *Appetite*
Potential Mechanisms through which Physical Activity Energy Expenditure Influences and Energy Intake and Body Weight

- Physical Activity
- Metabolic Parameters
  - Hunger & Satiety
  - Energy Intake
- Energy Expenditure
- Body Weight
Key Health Areas of Interest

Cardiovascular Disease
Weigh in on HEART HEALTH
Influence of Weight/Body Composition and Fitness on Left Ventricular Mass

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Variable</th>
<th>Step</th>
<th>Beta</th>
<th>S.E.</th>
<th>p-value</th>
<th>Partial $r^2$</th>
<th>Model $r^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Left Ventricular Mass</strong></td>
<td>Intercept</td>
<td></td>
<td>40.095</td>
<td>23.622</td>
<td>0.0905</td>
<td></td>
<td>0.6711</td>
</tr>
<tr>
<td></td>
<td>Age (years)</td>
<td>*</td>
<td>0.094</td>
<td>0.084</td>
<td>0.2631</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gender (female)</td>
<td>*</td>
<td>-10.781</td>
<td>2.904</td>
<td>0.0002</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Race (white)</td>
<td>*</td>
<td>-2.881</td>
<td>1.469</td>
<td>0.0507</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Height (cm)</td>
<td>*</td>
<td>-0.135</td>
<td>0.132</td>
<td>0.3092</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weight (kg)</td>
<td>1</td>
<td>0.779</td>
<td>0.095</td>
<td>&lt;0.0001</td>
<td>0.1200</td>
<td></td>
</tr>
<tr>
<td></td>
<td>% Body Fat</td>
<td>2</td>
<td>-0.847</td>
<td>0.212</td>
<td>&lt;0.0001</td>
<td>0.0253</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean Arterial Pressure</td>
<td>3</td>
<td>0.364</td>
<td>0.075</td>
<td>&lt;0.0001</td>
<td>0.0189</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fitness (oxygen consumption, L·min⁻¹)</td>
<td>4</td>
<td>5.520</td>
<td>2.137</td>
<td>0.0102</td>
<td>0.0059</td>
<td></td>
</tr>
</tbody>
</table>

*Indicates these variables were forced in the model during the stepwise regression analysis.
Physical Activity and Cardiovascular Disease in the Look AHEAD Study

Baseline Physical Activity

Year 1 Physical Activity

Year 4 Physical Activity

Primary and Secondary Outcomes that Occur After Year 1

Primary and Secondary Outcomes that Occur After Year 4
Physical Activity and Cardiovascular Disease in the Look AHEAD Study

- Baseline Physical Activity
- Year 1 Physical Activity
- Year 4 Physical Activity
- Primary and Secondary Outcomes that Occur After Year 1
- Primary and Secondary Outcomes that Occur After Year 4
Physical Activity and Cardiovascular Disease in the Look AHEAD Study

- Baseline Physical Activity
- Year 1 Physical Activity
- Year 4 Physical Activity
- Primary and Secondary Outcomes that Occur After Year 1
- Primary and Secondary Outcomes that Occur After Year 4
# Change in Physical Activity and CVD Risk in the Look AHEAD Study

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Physical Activity Variable</th>
<th>1-Year Hazard Ratio* (based on change in Physical Activity per 100 MET-minutes)</th>
<th>4-Year Hazard Ratio* (based on change in Physical Activity per 100 MET-minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary</strong></td>
<td>Baseline</td>
<td>0.975 (0.950, 1.001)</td>
<td>0.948 (0.906, 0.993)</td>
</tr>
<tr>
<td></td>
<td>Change at 1 Year</td>
<td>1.001 (0.985, 1.017)</td>
<td>0.958 (0.918, 1.000)</td>
</tr>
<tr>
<td><strong>Secondary Outcome</strong>*</td>
<td>Baseline</td>
<td>0.964 (0.932, 0.997)</td>
<td>0.892 (0.830, 0.959)</td>
</tr>
<tr>
<td></td>
<td>Change at 1 Year</td>
<td>0.989 (0.965, 1.013)</td>
<td>0.905 (0.844, 0.969)</td>
</tr>
</tbody>
</table>

*Fully adjusted model (age, sex, history of CVD, duration of diabetes, diabetes medication use, baseline weight, change in weight

*Primary Outcome: (non-fatal MI, stroke, hospitalized angina, CVD death)

**Secondary Outcome: (non-fatal MI, stroke, hospitalized angina, CABG/PTCA, hospitalized CHF, carotid endarterectomy, PVD, total mortality)

Jakicic, et al. (unpublished)
Key Health Areas of Interest

Type 2 Diabetes Mellitus
4-Year Change in HbA1c by Category of 4-Year Percent Change in Fitness

-0.40  -0.30  -0.20  -0.10  0.00  0.10  0.20

DSE and ILI Combined

P<0.0001

DSE

P<0.0001

ILI

P<0.01

>10% decline in fitness
0% to 10% decline in fitness
>0% to 10% increase in fitness
>10% increase in fitness
Missing Fitness at Year 4

4-Year Change in HbA1c by 4-Year Percent Change in Fitness Adjusted for 4-Year Weight Change.
4-Year Change in HbA1c by 4-Year Percent Change in Fitness Adjusted for Age, Gender, Weight Change and Diabetes Medication Use

“Patterns” of Physical Activity
Continuous vs. Intermittent Bouts of Physical Activity

Acute Response of Exercise on Insulin

Sedentary Behavior
Benefits of Standing versus Sitting

Healy GN, Winkler EAH, Owen N, Anuradha S, Dunstan DW. Replacing sitting time with standing or stepping: associations with cardiometabolic risk biomarkers. *European Heart Journal*. First published online: 30 July 2015

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Sit to Stand</th>
<th>Sit to Step</th>
<th>Stand to Step</th>
<th>RR (95% CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body Mass Index, kg/m²</td>
<td></td>
<td></td>
<td></td>
<td>RR = 0.99 (0.97, 1.02)</td>
<td>p = 0.528</td>
</tr>
<tr>
<td></td>
<td>RR = 0.90 (0.86, 0.95)</td>
<td>p &lt; 0.001</td>
<td></td>
<td>RR = 0.91 (0.86, 0.96)</td>
<td>p = 0.002</td>
</tr>
<tr>
<td>Waist circumference, cm</td>
<td>β = -0.53 (-3.08, 2.05)</td>
<td>p = 0.508</td>
<td></td>
<td>β = -7.48 (-10.80, -4.17)</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td></td>
<td>β = -6.97 (-11.05, -2.89)</td>
<td>p = 0.001</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fasting glucose, mmol/L</td>
<td>RR = 0.98 (0.97, 1.00)</td>
<td>p = 0.047</td>
<td></td>
<td>RR = 0.98 (0.95, 1.02)</td>
<td>p = 0.348</td>
</tr>
<tr>
<td></td>
<td>RR = 1.00 (0.97, 1.04)</td>
<td>p = 0.965</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HDL cholesterol, mmol/L</td>
<td>β = 0.06 (0.02, 0.09)</td>
<td>p = 0.002</td>
<td></td>
<td>β = 0.10 (0.02, 0.18)</td>
<td>p = 0.014</td>
</tr>
<tr>
<td></td>
<td>β = 0.04 (-0.05, 0.14)</td>
<td>p = 0.373</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total/HDL cholesterol ratio</td>
<td>RR = 0.94 (0.92, 0.97)</td>
<td>p &lt; 0.001</td>
<td></td>
<td>RR = 0.97 (0.92, 1.03)</td>
<td>p = 0.306</td>
</tr>
<tr>
<td></td>
<td>RR = 1.04 (0.97, 1.11)</td>
<td>p = 0.322</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Triglycerides, mmol/L</td>
<td>RR = 0.90 (0.87, 0.94)</td>
<td>p &lt; 0.001</td>
<td></td>
<td>RR = 0.88 (0.78, 0.98)</td>
<td>p = 0.020</td>
</tr>
<tr>
<td></td>
<td>RR = 0.98 (0.86, 1.11)</td>
<td>p = 0.726</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2hr postload glucose, mmol/L</td>
<td>RR = 0.99 (0.96, 1.02)</td>
<td>p = 0.396</td>
<td></td>
<td>RR = 0.89 (0.84, 0.94)</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td></td>
<td>RR = 0.90 (0.84, 0.97)</td>
<td>p = 0.005</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Energy Expenditure
Sitting versus Standing (15 minutes)

Activities with the same letter are significantly different at p<0.05

Creasy SA, Rogers RJ, Byard T, Kowalsky R, Jakicic JM. Energy Expenditure during Acute Periods of Sitting, Standing, and Walking. *Journal of Physical Activity and Health*
Wearable Technology

**Graph:**

- **Weight Change (kg)**
- **Months**
- **P-Values**
  - Group: 0.9648
  - Time: 0.0125
  - Group X Time: 0.1145

**Legend:**

- **SBWL (N=14)**
- **TECH (N=12)**
- **EN-TECH (N=13)**
Effect of Wearable Technology Combined With a Lifestyle Intervention on Long-term Weight Loss

The IDEA Randomized Clinical Trial

John M. Jakicic, PhD; Kelliann K. Davis, PhD; Renee J. Rogers, PhD; et al

Change in Body Weight by Group

P-Values
Weight Change Group: 0.07
Time: <0.001
Weight Change Group X Time: 0.003

Jakicic et al. JAMA. 2016
Concluding Comments
New Opportunities at the University of Pittsburgh
• A national research consortium designed to discover and perform preliminary characterization of the range of molecular transducers (the "molecular map") that underlie the effects of physical activity in humans.

• The program's goal is to study the molecular changes that occur during and after exercise and ultimately to advance the understanding of how physical activity improves and preserves health.

• The six-year program is the largest targeted NIH investment of funds into the mechanisms of how physical activity improves health and prevents disease.
Why is MoTrPAC Important?

Physical Activity ➔ Risk Factors, Fitness, Body Composition, etc. ➔ Health Outcome

Molecular Pathways / Transducers
University of Pittsburgh
Healthy Lifestyle Institute

WWW.LIFESTYLEINSTITUTE.PITT.EDU
Thank You!