Everyday Physical Activity and Its Role in Preventing Obesity

Kathleen F. Janz
Department of Health & Human Physiology, Department of Epidemiology, University of Iowa
Outline

• Value of Observational (Epidemiological) Studies for Understanding Physical Activity (PA) & Adiposity
• PA as an Explanatory Variable for Adiposity
• Adiposity as an Explanatory Variable for PA
• Developmental Trajectories for PA and Adiposity
• Implications for Public Policy
Cross-sectional Studies:
Measure Explanatory and Outcome Variables -
Same Time (Once)

Prospective Longitudinal Studies:
Measure Variables - Two or More Occasions

• Support inferences of cause and effect
• Complement randomized controlled trials (RCTs) by providing information on real world (everyday) physical activity dimensions, domains, & patterns in relationship to adiposity.

Longitudinal data require special statistical methods since observations within an individual tend to be intercorrelated.
Observational Studies Provide Unique Information

- Knowing the dimensions, timing, & pattern of real world associations among PA, sedentary time, & fatness has implications
  - Individual-level exercise prescription strategies to prevent obesity (dose-response)
  - Population-level public health guidelines (dose-response & practicality)
PA as an Explanatory Variable for Adiposity

I used to think correlation implied causation.

Then I took a statistics class. Now I don't.

Sounds like the class helped. Well, maybe.
Iowa Bone Development Study

\( n \sim 500, \text{5 to 21 yr, 16 yr follow-up, 8 exams} \)
Iowa Bone Development Study: Measuring Physical Activity from Childhood to Early Adulthood

ActiGraph accelerometer
Physical activity questionnaire
Iowa Bone Development Study: Measuring Adiposity from Childhood to Early Adulthood

Dual-energy X-ray Absorptiometry (DXA)
<table>
<thead>
<tr>
<th>Age</th>
<th>Gender</th>
<th>BW</th>
<th>BF</th>
<th>BF%</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 y</td>
<td>F</td>
<td>13.4 kg</td>
<td>3.1 kg</td>
<td>23.1%</td>
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<tr>
<td>8 y</td>
<td>F</td>
<td>19.8 kg</td>
<td>4.8 kg</td>
<td>24.2%</td>
</tr>
<tr>
<td>10 y</td>
<td>F</td>
<td>25.6 kg</td>
<td>6.4 kg</td>
<td>25%</td>
</tr>
<tr>
<td>12 y</td>
<td>F</td>
<td>32.3 kg</td>
<td>6.3 kg</td>
<td>19.5%</td>
</tr>
<tr>
<td>14 y</td>
<td>F</td>
<td>36.6 kg</td>
<td>7.1 kg</td>
<td>19.4%</td>
</tr>
<tr>
<td>5 y</td>
<td>M</td>
<td>19.0 kg</td>
<td>3.3 kg</td>
<td>17.4%</td>
</tr>
<tr>
<td>9 y</td>
<td>M</td>
<td>49.5 kg</td>
<td>25.3 kg</td>
<td>51.1%</td>
</tr>
<tr>
<td>11 y</td>
<td>M</td>
<td>73.8 kg</td>
<td>33.3 kg</td>
<td>45.4%</td>
</tr>
<tr>
<td>13 y</td>
<td>M</td>
<td>94.6 kg</td>
<td>41.6 kg</td>
<td>45.4%</td>
</tr>
<tr>
<td>15 y</td>
<td>M</td>
<td>101.1 kg</td>
<td>38 kg</td>
<td>37.6%</td>
</tr>
</tbody>
</table>

**IBDS**

2/3 cohort healthy adiposity 19 yr

22% cohort became obese 19 yr (32% BF females, 25% BF males)

12% obese at age 5
Timing & Tempo of Change is a Challenge in Longitudinal Research
MVPA, Sedentary Time, TV Viewing as Explanatory Variables of Adiposity, n=438, 5 to 17 yr, Multi-level Regression Models

Level 1 Random Effects Growth Curves
Each Individual (slope and intercept) Adiposity Outcome

Level 2 By Gender Fixed Effects to Predict Total Adiposity and Visceral Adiposity from MVPA, Sedentary Time, TV Viewing with Adjustment for Age, Height & Maturity
Multi-Level Model: Effect of Sedentary Time, TV Viewing, MVPA on Adiposity (kg) IBDS Females, n=219, 5 to 17 yr

<table>
<thead>
<tr>
<th></th>
<th>beta</th>
<th>SE</th>
<th>probability</th>
<th>probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-20.240</td>
<td>4.590</td>
<td>&lt;.0001</td>
<td>AIC 6064.5</td>
</tr>
<tr>
<td>Cent age yr</td>
<td>0.488</td>
<td>0.117</td>
<td>&lt;.0001</td>
<td></td>
</tr>
<tr>
<td>Cent age* yr</td>
<td>0.055</td>
<td>0.011</td>
<td>&lt;.0001</td>
<td></td>
</tr>
<tr>
<td>Ht cm</td>
<td>0.239</td>
<td>0.030</td>
<td>&lt;.0001</td>
<td></td>
</tr>
<tr>
<td>Maturity yr +-PHV</td>
<td>-0.142</td>
<td>0.353</td>
<td>0.6868</td>
<td></td>
</tr>
<tr>
<td>Sedentary Time hr/d</td>
<td>-0.172</td>
<td>0.101</td>
<td>0.0889</td>
<td></td>
</tr>
<tr>
<td>TV Viewing hr/d</td>
<td>0.310</td>
<td>0.093</td>
<td>0.0009</td>
<td></td>
</tr>
<tr>
<td>MVPA min/d</td>
<td>-0.025</td>
<td>0.007</td>
<td>0.0003</td>
<td></td>
</tr>
</tbody>
</table>
% Difference Adiposity at 11 yr: Low to High MVPA, n=405

% difference
fat

Girls
Boys

Low MVPA Vs High MVPA

7.5
5
% Difference Adiposity at 11 yr: Low to High MVPA & High to Low TV, n=405
% Difference Adiposity at 11 yr: Low to High MVPA, High to Low TV, & High MVPA/Low TV to Low MVPA/High TV, n=405

- Low MVPA Vs High MVPA: 7.5% for Girls, 5% for Boys
- High TV Vs Low TV: 5% for Girls, 9.3% for Boys
- Low MVPA & High MVPA & Low TV: 11.8% for Girls, 21.3% for Boys
Prospective Longitudinal Studies on Physical Activity, Sedentary Time, & Adiposity

- **Seven** prospective studies physical activity (accelerometers)
  - 6 negative association, 1 no association
  - Of 7, 2 criterion adiposity measure (DXA)

- **Four** prospective studies sedentary time (accelerometers)
  - 1 positive association, 3 no association
  - Of 4, 1 criterion adiposity measure (DXA)
Nine longitudinal studies (3 prospective) sedentary time (accelerometers) associated with adiposity
- 8 no association, 1 association at 90th, 75th & 50th percentiles BMI
- Of nine, 4 criterion measure adiposity (DXA)

Eight longitudinal studies (2 prospective) TV viewing (self report) associated with adiposity
- 5 positive association, 3 no association,
- Of 8, 1 criterion adiposity measure (DXA)

Ekelund et al Proceedings of the Nutrition Society 2014
Cross-sectional International Study on Physical Activity, Sedentary Time, & Obesity

- 6,539 children ages 9 to 11 yr at 12 sites
  - Australia, Brazil, Canada, China, Colombia, Finland, India, Kenya, Portugal, South Africa, United Kingdom & U.S.

Accelerometers to measure MVPA, VPA, & sedentary time

WHO body mass index to determine obesity

*Katzmarzyk al MSSE ahead of press 2015*
Cross-sectional International Study on Physical Activity, Sedentary Time, & Obesity, n=6,539, 9 to 11 yr, 2 yr follow-up

Best predictor of lower obesity 55 min/d MVPA

Katzmarzyk et al MSSE ahead of press, 2015
Adiposity as an Explanatory Variable for PA

"No, you back off! I was here before you!"
Adiposity Predicts Future MVPA, n=202, 7 to 10 yr, 3 yr follow-up

<table>
<thead>
<tr>
<th></th>
<th>Partial r (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MVPA at age 7 vs change %BF age 7 to 10</td>
<td>-0.01 (-0.15 to +0.13)</td>
</tr>
<tr>
<td>% BF age 7 vs change in MVPA age 7 to 10</td>
<td>-0.17 (-0.30 to -0.03)</td>
</tr>
</tbody>
</table>

Controlled for sex, age & current outcome variable

10% difference in adiposity at 7 yr
4 min less MVPA/d at 10 yr

Metcalf et al Arch Dis Childhood 2009
Effects of Adiposity on Physical Activity in Childhood: Iowa Bone Development Study

SOYANG KWON¹, KATHLEEN F. JANZ²,³, TRUDY L. BURNS³,⁴, and STEVEN M. LEVY³,⁵

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DOI: 10.1249/MSS.0b013e3181ef3b0a

Assessing Causality in the Association between Child Adiposity and Physical Activity Levels: A Mendelian Randomization Analysis

Rebecca C. Richmond¹, George Davey Smith¹, Andy R. Ness², Marcel den Hoed³, George McMahon¹, Nicholas J. Timpson¹*

PEDIATRIC ORIGINAL ARTICLE

Fatness predicts decreased physical activity and increased sedentary time, but not vice versa: support from a longitudinal study in 8- to 11-year-old children

MF Hjorth¹, J-P Chaput², C Ritz¹, S-M Dalskov¹, R Andersen³, A Astrup¹, I Tetens³, KF Michaelsen¹ and A Sjödin¹

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Developmental Trajectories for PA and Adiposity
Mean MVPA Minutes & 95% Confidence Intervals, n=365, 5 to 15 yr
Mean MVPA Minutes & 95% Confidence Intervals by MVPA Trajectory Groups, n=537, 5 to 19 yr

1. Consistently Low Active
   - 14.9% of the population

2. Consistently Active
   - 18.1% of the population

3. Decreasing Medium MVPA
   - 52.9% of the population

4. Substantially Decreasing High MVPA
   - 14.1% of the population
Females Mean % Body Fat & 95% Confidence Intervals by % Body Fat Trajectory Groups, n=251, 5 to 19 yr

1. Healthy
2. Healthy
3. Became Obese
4. Obese

Body Fat % (%BF)

Age (years)
Males Mean % Body Fat & 95% Confidence Intervals by % Body Fat Trajectory Groups, n=242, 5 to 19 yr

1. Healthy
2. Healthy
3. Became Obese
4. Obese

Age (years)

% BF

Body fat %

1  31.1%
2  43.6%
3  14.6%
4  10.7%
Females & Males Mean % Body Fat & 95% Confidence Intervals by % Body Fat Trajectory Groups, n=493, 5 to 19 yr

Before Age 5: 12% Cohort Obese (n=60) & Most Stayed That Way
Multinomial Logistic Regression (Odd Ratio) Estimates of *Becoming* Obese by MVPA Trajectory Groups
Adjusted for Mother’s Education, Maturity, Energy Intake

<table>
<thead>
<tr>
<th>Effect</th>
<th>OR</th>
<th>95th CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consistently inactive vs. decreasing medium MVPA</td>
<td>1.34</td>
<td>0.66  2.72</td>
</tr>
<tr>
<td>Substantially decreasing high MVPA vs. decreasing medium MVPA</td>
<td>0.83</td>
<td>0.38  1.81</td>
</tr>
<tr>
<td>Consistently active vs. decreasing medium MVPA</td>
<td>0.40</td>
<td>0.17  0.94</td>
</tr>
</tbody>
</table>

23% consistently inactive became obese by 19 yr
24% decreasing medium MVPA
10% decreasing high MVPA
9% consistently active *(45 min/d MVPA)*
Throughout the growing years:
Public Policy Implications

• MVPA & TV viewing predict adiposity: sedentary time less important.
  • Support guidelines emphasize 60 min/d MVPA & 2 hours or less TV viewing.
Through out the growing years: Public Policy Implications

• Adiposity predicts future levels of MVPA
  • For some children, age 5 is too late
    • Strategies for increasing MVPA in already obese may differ
  • True prevention for some must start early in life
• Understand possibility of healthy metabolic profiles in overweight and obese
The Good News

• State-of-the-Art prospective longitudinal studies offer an understanding of the development of obesogenic behaviors in youth
• Subset of youth sustain a healthy level of MVPA from childhood to young adulthood (both girls & boys)
• Youth who are active everyday through out childhood and adolescence are less likely to become obese as adults than inactive peers or peers decreasing activity with age

Some families are doing it right, let’s learn from them
Thank you

This work was supported by the National Institute of Dental & Craniofacial Research (R01-DE12101 & R01-DE09551) & the National Center for Research Resources (UL1 RR024979 and M01-RR00059).

On behalf of the IBDS investigators with special thanks to the children, parents, and staff of Iowa Bone Development Study.
Contact me at kathleen-janz@uiowa.edu if you would like papers cited today including overviews of multi-level models and group-based trajectory models. Thank you for inviting me.

IOM Associates you were wonderful to work with.

Former Iowa Bone Development Study Model & Former Most Excellent Girl Next Door
Now IOM Research Associate Sarah Ziegenhorn
## Iowa Bone Development Study n = 493

<table>
<thead>
<tr>
<th></th>
<th>Wave 1 Mean</th>
<th>Wave 2 Mean</th>
<th>Wave 3 Mean</th>
<th>Wave 4 Mean</th>
<th>Wave 5 Mean</th>
<th>Wave 6 Mean</th>
<th>Wave 7 Mean</th>
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</thead>
<tbody>
<tr>
<td><strong>Males N</strong></td>
<td>176</td>
<td>227</td>
<td>231</td>
<td>219</td>
<td>192</td>
<td>180</td>
<td>144</td>
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<tr>
<td>Age at scan</td>
<td>5.2</td>
<td>8.8</td>
<td>11.2</td>
<td>13.3</td>
<td>15.4</td>
<td>17.5</td>
<td>19.7</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>20.4</td>
<td>33.4</td>
<td>45.4</td>
<td>57.9</td>
<td>70.8</td>
<td>79.1</td>
<td>83.7</td>
</tr>
<tr>
<td>% Body fat</td>
<td>29.6</td>
<td>28.1</td>
<td>28.6</td>
<td>26.3</td>
<td>22.2</td>
<td>21.8</td>
<td>23.4</td>
</tr>
<tr>
<td>MVPA, min/day</td>
<td>50.0</td>
<td>58.5</td>
<td>58.9</td>
<td>46.9</td>
<td>33.6</td>
<td>32.9</td>
<td>37.4</td>
</tr>
<tr>
<td>Sedentary, h/day</td>
<td>4.6</td>
<td>5.4</td>
<td>5.8</td>
<td>6.7</td>
<td>8.3</td>
<td>8.4</td>
<td>8.3</td>
</tr>
<tr>
<td>TV, h/day</td>
<td>2.3</td>
<td>2.2</td>
<td>2.4</td>
<td>2.3</td>
<td>2.2</td>
<td>2.1</td>
<td>2.0</td>
</tr>
<tr>
<td><strong>Females N</strong></td>
<td>203</td>
<td>242</td>
<td>241</td>
<td>219</td>
<td>186</td>
<td>186</td>
<td>171</td>
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<tr>
<td>Age at scan</td>
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<td>8.7</td>
<td>11.2</td>
<td>13.2</td>
<td>15.3</td>
<td>17.5</td>
<td>19.6</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>20.0</td>
<td>31.8</td>
<td>44.7</td>
<td>55.7</td>
<td>62.0</td>
<td>67.2</td>
<td>68.4</td>
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<tr>
<td>% Body fat</td>
<td>33.4</td>
<td>32.4</td>
<td>31.0</td>
<td>30.3</td>
<td>31.2</td>
<td>33.0</td>
<td>34.4</td>
</tr>
<tr>
<td>MVPA, min/day</td>
<td>39.1</td>
<td>41.2</td>
<td>36.2</td>
<td>30.0</td>
<td>23.0</td>
<td>22.6</td>
<td>30.1</td>
</tr>
<tr>
<td>Sedentary, h/day</td>
<td>4.7</td>
<td>5.5</td>
<td>6.0</td>
<td>7.1</td>
<td>8.6</td>
<td>8.6</td>
<td>8.4</td>
</tr>
<tr>
<td>TV, h/day</td>
<td>2.3</td>
<td>2.0</td>
<td>2.1</td>
<td>2.2</td>
<td>1.8</td>
<td>1.7</td>
<td>1.8</td>
</tr>
</tbody>
</table>
Mean TV Viewing Hours & 95% Confidence Intervals by TV Viewing Trajectory Classes n=537, 5 to 19 yr

1. Decreasing low TV viewing
2. Increasing low TV viewing
3. Decreasing high TV viewing
4. Maintaining high TV viewing

Kwon JAMA Ped in press
## Distribution of MVPA Trajectory Classes (n, %) by TV Viewing Trajectory Classes

<table>
<thead>
<tr>
<th>TV 1</th>
<th>MVPA 1 Consistently inactive</th>
<th>MVPA 2 Healthiest Consistently active</th>
<th>MVPA 3 Decreasing moderate MVPA</th>
<th>MVPA 4 Substantially decreasing high MVPA</th>
<th>Chi-square p*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthiest Decreasing low TV</td>
<td>9 (7%)</td>
<td>42 (31%)</td>
<td>65 (48%)</td>
<td>19 (14%)</td>
<td>Reference</td>
</tr>
<tr>
<td>TV 2</td>
<td>16 (12%)</td>
<td>17 (12%)</td>
<td>71 (52%)</td>
<td>33 (24%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Increasing low TV</td>
<td>34 (22%)</td>
<td>17 (11%)</td>
<td>85 (55%)</td>
<td>18 (12%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>TV 3</td>
<td>11 (10%)</td>
<td>3 (3%)</td>
<td>91 (82%)</td>
<td>6 (5%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Decreasing high TV</td>
<td>Maintaining high TV</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Chi-square test of whether the proportion of MVPA Group 2 was different between TV Group 1 (reference group) and other TV Groups.

_Kwon JAMA Ped in press_
Multinomial Logistic Regression for *Becoming* Obese Trajectory According to TV Viewing Trajectories Adjusted Mother’s Education & Maturity

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Estimate</th>
<th>95% Wald CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing low TV viewing vs reducing low TV viewing</td>
<td>2.2</td>
<td>1.1 4.4</td>
</tr>
<tr>
<td>Decreasing high TV viewing vs reducing low TV viewing</td>
<td>1.9</td>
<td>0.9 3.8</td>
</tr>
<tr>
<td>Maintaining high TV viewing vs reducing low TV viewing</td>
<td>3.1</td>
<td>1.5 6.4</td>
</tr>
</tbody>
</table>
Multinomial Logistic Regression for *Already* Obese Trajectory According to TV Viewing Trajectories

<table>
<thead>
<tr>
<th>Trajectory Comparison</th>
<th>Estimate</th>
<th>95% Wald CI</th>
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<tbody>
<tr>
<td>Increasing low TV viewing vs reducing low TV viewing</td>
<td>5.7</td>
<td>1.8 18.7</td>
</tr>
<tr>
<td>Decreasing high TV viewing vs reducing low TV viewing</td>
<td>6.0</td>
<td>2.0 18.8</td>
</tr>
<tr>
<td>Maintaining high TV viewing vs reducing low TV viewing</td>
<td>5.6</td>
<td>1.7 18.7</td>
</tr>
</tbody>
</table>
Imaging Adiposity Across Time

4 yr F  
13.4 kg BW  
3.1 kg BF  
23.1%

8 yr F  
19.8 kg BW  
4.8 kg BF  
24.2%

10 yr F  
25.6 kg BW  
6.4 kg BF  
25.0%

12 yr F  
32.3 kg BW  
6.3 kg BF  
19.5%

14 yr F  
36.6 kg BW  
7.1 kg BF  
19.4%
Imaging Adiposity Across Time

5 yr M
19.0 kg BW
3.3 kg BF
17.4%

9 yr M
49.5 kg BW
25.3 kg BF
51.1%

11 yr M
73.3 kg BW
33.3 kg BF
45.4%

13 yr M
94.6 kg BW
41.6 kg BF
45.4%

15 yr M
101.1 kg BW
38 kg BF
37.6%
Mean Sedentary Time (% of Waking Day) & 95% Confidence Intervals n=537, 5 to 19 yr
“If you want to measure change, don’t change the measure.” OD Dugan, 1969

Change of ActiGraph accelerometer models 3x
  age 5 – 13 #7164
  age 15 #GT1M
  age 17 – present #GT3X+

Change of PA questionnaire 2x
  age 5 – 8 parent proxy report
  age 11 – present participant report

Change of DXA scanner 3x
  age 5 - 8 Hologic 2000
  age 11 – 15 Hologic 4500
  age 17 – present Hologic Discovery
Strengths and Limitations

- Modeled same kids over 12 year period
- Criterion measure adiposity
- Objective measure activity
- Careful follow-up and screens of parent and self-reports
- Homogeneity of sample reduced confounding other factors

- Mostly white kids from US Midwest
- Bias in reports of sedentary behaviors
- Loss of participants
- Limitations of accelerometers
Tracking Moderate and Vigorous Intensity Physical Activity (MVPA) Accelerometer Mean & 95% CI: Iowa Bone Development Study, n=365, 5 to 15 yr

Francis et al., MSSE 2013