Association of the Degree of Adiposity and Duration of Obesity with Cardiac Structure and Function: The CARDIA Study

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FINANCIAL DISCLOSURE:
No relevant financial relationship exists
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<thead>
<tr>
<th>Co-Authors</th>
<th>Affiliations</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Northwestern University</td>
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<td>NHLBI</td>
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<td>NHLBI</td>
</tr>
<tr>
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<td>Northwestern University</td>
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</tbody>
</table>
Obesity Trends in the United States, 1971-2012

Source: This graph shows data from the Centers for Disease Control and Prevention (CDC), National Health and Nutrition Examination Surveys (NHANES).
Background

- Greater degree of overall and abdominal adiposity
  - Blood volume
  - Concentric left ventricular (LV) remodeling
    - LV mass, increased/preserved cavity size
  - Overt heart failure

- Individuals becoming obese at a younger age than in previous generations; more of their lifetime obese

- Few studies have determined the consequences of a longer duration of obesity
To examine whether there are independent influences of a **greater degree** of adiposity and a **longer duration** of obesity on **cardiac structure and function** in middle-age.
The CARDIA Study

- Ideal to study the impact of a greater degree of adiposity and longer duration of obesity as a result of the obesity epidemic
  - Recruited in the mid-1980’s during the start of the epidemic
  - Continuously followed with repeat examinations for 25 years
  - Followed during the period of greatest gain in adiposity (i.e., young adulthood to middle-age)
CARDIA Study:
- Population based cohort study in 4 US cities
- N=5,115, 18-30 years old in 1985-6
- Balanced on age, sex, race (B/W), education
- Follow-up exams 2, 5, 7, 10, 15, 20, and 25 yrs later (retention: 72% at Year 25)

Study sample (n=2,547):
- Available measures of cardiac structure/function Year 25
- Without obesity at baseline or clinical CHD, heart failure, or bariatric surgery through Year 25
- Were not pregnant at any exam
Duration of Obesity

- Measured weight, height, and waist circumference
  - Overall obesity: BMI ≥30 kg/m²
  - Abdominal obesity: Waist >102 cm (men) and >88 cm (women)
- Calculated for those who were not overall or abdominally obese at baseline
- Based on presence of obesity at each follow-up and the preceding exam

<table>
<thead>
<tr>
<th></th>
<th>Y0</th>
<th>Y2</th>
<th>Y5</th>
<th>Y7</th>
<th>Y10</th>
<th>Y15</th>
<th>Y20</th>
<th>Y25</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obese?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Yrs</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>17</td>
</tr>
</tbody>
</table>
Outcomes & Other Measurements

- **Outcomes:**
  - 2D echocardiography Year 25
    - LV mass, LV mass/volume, left atrial (LA) dimension, ejection fraction

- **Other measurements:**
  - Average Year 0-25 systolic blood pressure, physical activity, and alcohol use
    - Updated smoking information
    - Diabetes and antihypertensive meds Year 0-25
    - Heart rate Year 25
Overall and Abdominal Obesity, Year 25

Body mass index (kg/m²)

- <18.5
- 18.5-24.9
- 25.0-29.9
- 30.0-34.9
- ≥35.0

Percent

Abdominal obesity
Duration of Obesity, Year 0-25

Overall Obesity
Mean duration: 14 yrs
Mean age at onset: 36 yrs

Abdominal Obesity
Mean duration: 13 yrs
Mean age at onset: 38 yrs
## Factors Associated with a Longer Duration

<table>
<thead>
<tr>
<th></th>
<th>Duration of overall obesity (yrs)</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>P-trend</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>1-5</td>
<td>6-10</td>
<td>11-15</td>
<td>16-20</td>
<td>&gt;20</td>
<td></td>
</tr>
<tr>
<td>Age, baseline, yrs</td>
<td>25.1</td>
<td>24.5</td>
<td>25.1</td>
<td>24.9</td>
<td>24.2</td>
<td>24.8</td>
<td>0.003</td>
</tr>
<tr>
<td>Women, %</td>
<td>52</td>
<td>54</td>
<td>54</td>
<td>55</td>
<td>55</td>
<td>58</td>
<td>0.07</td>
</tr>
<tr>
<td>Black, %</td>
<td>35</td>
<td>49</td>
<td>53</td>
<td>59</td>
<td>62</td>
<td>71</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Max education, yrs</td>
<td>16.0</td>
<td>15.7</td>
<td>15.5</td>
<td>15.6</td>
<td>15.5</td>
<td>15.1</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Ever smoker, %</td>
<td>39</td>
<td>41</td>
<td>39</td>
<td>35</td>
<td>36</td>
<td>34</td>
<td>0.09</td>
</tr>
<tr>
<td>Physical activity</td>
<td>366</td>
<td>324</td>
<td>316</td>
<td>293</td>
<td>289</td>
<td>273</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Alcohol, ml/day</td>
<td>7</td>
<td>5</td>
<td>7</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>
Degree of Overall Adiposity and Cardiac Structure and Function

Means adjusted for duration of obesity, age, sex, race, education, center, smoking, activity, alcohol, SBP, blood pressure medication use, heart rate, and diabetes.
Duration of Overall Obesity and Cardiac Structure and Function

Means adjusted for degree of overall adiposity, age, sex, race, education, center, smoking, activity, alcohol, SBP, blood pressure medication use, heart rate, and diabetes.
Degree of Abdominal Adiposity and Cardiac Structure and Function

Waist Quintiles at Year 25

- LV Mass (g)
  - Quintile I
  - Quintile II
  - Quintile III
  - Quintile IV
  - Quintile V

- LV Mass/Volume
  - Quintile I
  - Quintile II
  - Quintile III
  - Quintile IV
  - Quintile V

- LA Dimension (cm)
  - Quintile I
  - Quintile II
  - Quintile III
  - Quintile IV
  - Quintile V

- Ejection Fraction (%)
  - Quintile I
  - Quintile II
  - Quintile III
  - Quintile IV
  - Quintile V

Means adjusted for duration of abdominal obesity, age, sex, race, height, education, center, smoking, activity, alcohol, SBP, blood pressure medication use, heart rate, and diabetes.
Means adjusted for degree of abdominal adiposity, age, sex, race, height, education, center, smoking, activity, alcohol, SBP, blood pressure medication use, heart rate, and diabetes.
Summary

- Degree of overall and abdominal adiposity associated with several measures of cardiac structure
  - Greater LV mass, LV mass-to-volume ratio, LA size
- Duration overall obesity independently associated with greater LV mass
- Ejection fraction positively associated with degree of adiposity and inversely associated with duration of obesity
  - Suggests compensatory increase early on with increased adiposity and impaired systolic function with prolonged obesity
- Little evidence for substantial difference between white and black men and women (not shown)
Limitations

- Duration of obesity based on measurement every 2-5 years
  - More frequent assessments likely more accurate

- Some participants missing at least one measure of adiposity during follow-up
  - Similar results in sensitivity analyses using multiple imputation techniques
Conclusions

- Concentric LV remodeling (reflected by a higher LV mass/volume ratio) due to obesity results largely as a consequence of a greater degree of adiposity.

- Cumulative effects of long-term obesity, on the other hand, may contribute to concentric LV remodeling predominately by increasing LV mass.
NHLBI REPOSITORY DATA SETS AVAILABLE TO SCIENTIFIC COMMUNITY

- Description of data on Public CARDIA website:
  http://www.cardia.dopm.uab.edu
- Procedures on how to request data:
  https://biolincc.nhlbi.nih.gov/home/
- For Information or Questions on how to request data:
  biolincc@imsweb.com
- For Other Information or Questions, send an email to:
  CARDIAdataliaquestions@dopm.uab.edu
Trends in Obesity*, US Adults, 1960-2012

*BMI ≥ 30.0

Ogden et al. *JAMA* 2014;311:806-14.
Background

Figure 1. Trends in obesity among children and adolescents: United States, 1963–2008

NOTE: Obesity is defined as body mass index (BMI) greater than or equal to sex- and age-specific 95th percentile from the 2000 CDC Growth Charts.

### Degree of Overall Adiposity and Cardiac Structure and Function

<table>
<thead>
<tr>
<th>BMI (kg/m²) at Year 25</th>
<th>LVMI (g/m².7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;18.5</td>
<td></td>
</tr>
<tr>
<td>18.5-24.9</td>
<td></td>
</tr>
<tr>
<td>25-29.9</td>
<td></td>
</tr>
<tr>
<td>30-34.9</td>
<td></td>
</tr>
<tr>
<td>≥35</td>
<td>P(trend) &lt;0.001</td>
</tr>
</tbody>
</table>

Means are adjusted for duration of obesity, age, sex, race, education, center, smoking, activity, alcohol, SBP, blood pressure medication use, heart rate, and diabetes.
Means are adjusted for degree of overall adiposity, age, sex, race, education, center, smoking, activity, alcohol, SBP, blood pressure medication use, heart rate, and diabetes.
Degree of Abdominal Adiposity and Cardiac Structure and Function

Means are adjusted for duration of abdominal obesity, age, sex, race, height, education, center, smoking, activity, alcohol, SBP, blood pressure medication use, heart rate, and diabetes.
Duration of Abdominal Obesity and Cardiac Structure and Function

Means are adjusted for degree of abdominal adiposity, age, sex, race, height, education, center, smoking, activity, alcohol, SBP, blood pressure medication use, heart rate, and diabetes.
### Effect Modification by Race and Sex

<table>
<thead>
<tr>
<th>Cardiac Parameter</th>
<th>Exposure</th>
<th>P for interaction</th>
<th>β (per 5 yr)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LV mass</td>
<td>BMI</td>
<td>0.01</td>
<td>0.010</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>Duration of overall obesity</td>
<td>0.2</td>
<td>-0.016</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>Waist circumference</td>
<td>0.8</td>
<td>0.011</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>Duration abdominal obesity</td>
<td>0.9</td>
<td>0.012</td>
<td>0.3</td>
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<tr>
<td>LV mass/volume</td>
<td>BMI</td>
<td>0.01</td>
<td>0.007</td>
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<tr>
<td></td>
<td>Duration of overall obesity</td>
<td>0.007</td>
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<tr>
<td></td>
<td>Waist circumference</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Duration of abdominal obesity</td>
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<td></td>
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<tr>
<td>LA dimension</td>
<td>BMI</td>
<td>&lt;0.001</td>
<td>0.17</td>
<td>&lt;0.001</td>
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<tr>
<td></td>
<td>Duration of overall obesity</td>
<td>0.06</td>
<td>0.09</td>
<td>&lt;0.001</td>
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<tr>
<td></td>
<td>Waist circumference</td>
<td>0.2</td>
<td>0.01</td>
<td>&lt;0.001</td>
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<tr>
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<td>Duration of abdominal obesity</td>
<td>0.06</td>
<td>0.19</td>
<td>&lt;0.001</td>
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<tr>
<td>Ejection fraction</td>
<td>BMI</td>
<td>0.5</td>
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<tr>
<td></td>
<td>Duration of overall obesity</td>
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<tr>
<td></td>
<td>Waist circumference</td>
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<tr>
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<td>Duration of abdominal obesity</td>
<td>0.7</td>
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