Weighing in on Whole Grains: A review of Evidence Linking Whole Grains to Body Weight

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Scientist II
Weighing in on Whole Grains:
A review of Evidence Linking Whole Grains to Body Weight

Supported in part by an Investigator Initiated Research Grant from the General Mills Bell Institute of Health and Disease
Presentation Outline

- Background
- Scientific Evidence
  - Cross-sectional Studies
  - Prospective Studies
  - Intervention Studies
- Gaps in the Knowledge
We Live in an Obesogenic Environment

- High fat/energy dense foods
- ↑Soft drinks & excess sugar
- High glycemic index/glycemic load
- Low dietary fiber
- Fast foods readily available
- Reduction in physical activity
Modest Weight Loss With Lifestyle Intervention Prevents Diabetes

Overweight and Obese Persons with Impaired Glucose Tolerance

Cumulative Incidence of Diabetes (%)

Year

Placebo
-58%, p<0.001

Lifestyle

Potential Mechanisms of Whole Grains in Body Weight Regulation

- Satiety
  - Greater chewing/effort
  - Slower gastric emptying

- Influence glucose and insulin metabolism

- Gut hormones
  - GLP-1, PYY, CCK (satiety)
  - Ghrelin (hunger)
American Association of Cereal Chemists:

“Whole grains shall consist of the intact, ground, cracked or flaked caryopsis, whose principal anatomical components – the starchy endosperm, germ and bran – are present in the same relative proportions as they exist in the intact caryopsis”

http://www.aaccnet.org/definitions/wholegrain.asp
Dietary Exposure of Interest: Whole Grain Intake

- Food Frequency Questionnaires (FFQs)
  - Recall diet over the previous year
  - 9 responses, ranging from "never" to "≥6 times/d"

  - ≥25% whole-grain or bran content by weight
  - Classified as servings of whole grain–rich foods per day

  - Whole-grain expressed as grams per day
  - Expressed as grams of whole-grain content per RACC
  - FDA definition ≥ 51% whole grain per RACC
Outcome of Interest: Adiposity and Body Composition

- **Body Mass Index (BMI)** \[\text{wt (kg)/h (m)^2}\]
  - Index of overall adiposity

- **Waist circumference**
  - Good surrogate measure of abdominal adiposity

- **Dual Energy X-ray Absorptiometry (DXA)**
  - Specific ROI: Upper edge of the second lumbar vertebra to above the iliac crest provides a measure of trunk fat (%)
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Higher Intake of Whole Grains Associated with Lower BMI and Smaller Waist Circumference

<table>
<thead>
<tr>
<th>Reference</th>
<th>Country</th>
<th>Dietary Method</th>
<th>Higher WG Intake Associated (P&lt;0.05) with Lower BMI</th>
<th>Smaller WC</th>
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<tbody>
<tr>
<td><strong>ADULTS</strong></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>McKeown et al. (2002)</td>
<td>USA</td>
<td>FFQ</td>
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<td>Liu et al. (2003)</td>
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<td>Bazzano et al. (2005)</td>
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<td>Sayhoun et al. (2006)</td>
<td>USA</td>
<td>3-d record</td>
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<td>FFQ</td>
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<tr>
<td>Newby et al. (2007)</td>
<td>USA</td>
<td>7d FR</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Rose et al. (2007)</td>
<td>USA</td>
<td>7-d record (x2)</td>
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<td>Good et al. (2008)</td>
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<td>✓</td>
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<tr>
<td>McKeown et al. (2009)</td>
<td>USA</td>
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<td>Esmailzadeh et al. (2005a; 2005b)</td>
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<td>van de Vijver et al. (2009)</td>
<td>Netherlands</td>
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<td>Thane et al. (2009)</td>
<td>UK</td>
<td>7-d record</td>
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<td><strong>ADOLESCENTS</strong></td>
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<td>Steffen et al. (2003)</td>
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<td>Cheng et al. (2009)</td>
<td>Germany</td>
<td>3-d record</td>
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<td>—</td>
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<tr>
<td><strong>SUMMARY</strong></td>
<td>USA: 11/14</td>
<td>FFQ</td>
<td>12/14</td>
<td>4/5</td>
</tr>
</tbody>
</table>
Whole and Refined Grain Intake and % Abdominal Fat as Determined by DXA in Older Adults (60-80y)

Adjusted for age, sex, total energy intake, percent energy from fat, physical activity, smoking, alcohol intake, and multivitamin use.

Framingham Heart Study (2002 - 2005)  
n=3370 participants with CT measures of SAT & VAT  
Excluded those with diagnosed diabetes, invalid dietary information, and incomplete covariate information (n=2834)  
Diet assessed with semi-quantitative FFQ  
Grains defined as servings per day
Relation between Whole and Refined Gain Intakes and Waist Circumference in Middle-Aged Adults

McKeown et al. (2010) AJCN. 92:1165

Whole grain

Refined grain

P-trend <0.001

P-trend 0.06

Adjusted for:
- age
- sex
- smoking status
- total energy
- alcohol intake
Relation between Whole and Refined Gain Intakes and Waist Circumference in Middle-Aged Adults

McKeown et al. (2010) AJCN. 92:1165
Relation between Whole and Refined Gain Intakes and Visceral Adipose Tissue (VAT) Volume

VAT Volume (cm$^3$) vs Whole-grain intake (servings/d)$^3$

- Whole grain: $P$-trend $<0.0001$
- Refined grain: $P$-trend $<0.0001$

McKeown et al. (2010) AJCN. 92:1165
Relation between Whole and Refined Gain Intakes and Visceral Adipose Tissue (VAT) Volume

VAT Volume (cm³) vs. Refined-grain intake (servings/d)³

- Whole grain
  - P-trend <0.0001

- Refined grain
  - P-trend <0.0001

McKeown et al. (2010) AJCN. 92:1165
Relation between Whole and Refined Gain Intakes and Subcutaneous Adipose Tissue (SAT) Volume

McKeown et al. (2010) AJCN. 92:1165
Relation between Whole and Refined Gain Intakes and Subcutaneous Adipose Tissue (SAT) Volume

McKeown et al. (2010) AJCN. 92:1165

Refined grain
$P$-trend=$-0.60$

Whole grain
$P$-trend=$0.28$
Joint Classification of Whole- and Refined-Grain Intake on Visceral Adipose Tissue (VAT) Volume

McKeown et al. Am J Clin Nutr 2010; 92:1165
Presentation Outline

- Background
- Scientific Evidence
  - Cross-sectional Studies
  - Prospective Studies
  - Intervention Studies
- Gaps in the Knowledge
Prospective Evidence: Individuals Who Eat More Whole Grains Gain Less Weight

<table>
<thead>
<tr>
<th>Reference</th>
<th>Country</th>
<th>Study Characteristics</th>
<th>Higher WG Intake Associated with</th>
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</thead>
<tbody>
<tr>
<td></td>
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<td>Age</td>
<td>Diet Method</td>
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<td>Adults</td>
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<tr>
<td>Liu et al. (2003)</td>
<td>USA</td>
<td>38-63</td>
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<td>Koh-Banerjee et al. (2004)</td>
<td>USA</td>
<td>40-75</td>
<td>FFQ</td>
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<tr>
<td>Bazzano et al. (2005)</td>
<td>USA</td>
<td>40-84</td>
<td>FFQ</td>
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<tr>
<td>Du et al. (2010)</td>
<td>Europe</td>
<td>20-78</td>
<td>FFQ</td>
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<tr>
<td>Summary</td>
<td>USA: 3/4</td>
<td>FFQ</td>
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<tr>
<td>Adolescents</td>
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<td></td>
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<tr>
<td>Cheng et al. (2009)</td>
<td>Germany</td>
<td>8-15</td>
<td>3-d record</td>
</tr>
</tbody>
</table>
BMI (kg/m²) Lower in Women with High Whole Grain Intake: Evidence from the Nurses’ Health Study

Liu et al. (2003) AJCN 78:920-7
### Relationship between Grain Intake, Dietary Fiber and 12-Year Weight Gain in the Nurses Health Study

Liu et al. (2003) AJCN

<table>
<thead>
<tr>
<th></th>
<th>Weight change, kg</th>
<th>Odds Ratio of Weight gain &gt; 25 kg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Q1</td>
<td>Q5</td>
</tr>
<tr>
<td>Whole grain</td>
<td>4.51</td>
<td>4.12</td>
</tr>
<tr>
<td>Refined grain</td>
<td>4.25</td>
<td>4.68</td>
</tr>
<tr>
<td>Dietary fiber</td>
<td>5.16</td>
<td>3.64</td>
</tr>
</tbody>
</table>

Adjusted for age, change in exercise, smoking, alcohol, caffeine, use of HRT, total caloric intake, changes in SFA, PUFA, MUFA, trans and protein and baseline BMI.
**Average 8-Year Weight Change (kg) According to Quintiles of Change in Whole Grain Intake and Components of Whole Grains in Men**

<table>
<thead>
<tr>
<th></th>
<th>Quintiles of change in whole-grain intake (g/d)</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>3</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>From all foods</td>
<td>1.24 ± 0.23</td>
<td>1.03 ± 0.22</td>
<td>0.75 ± 0.22</td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Jacobs et al. definition</td>
<td>1.25 ± 0.22</td>
<td>1.28 ± 0.22</td>
<td>0.73 ± 0.22</td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>FDA definition</td>
<td>0.96 ± 0.22</td>
<td>0.96 ± 0.29</td>
<td>0.69 ± 0.21</td>
<td></td>
<td>0.002</td>
</tr>
</tbody>
</table>

For every 40 g/d increment in whole grain from all foods, weight gain was reduced by 0.49 kg.

Average 8-Year Weight Change (kg) According to Change in Added Bran, Added Germ and Dietary Fiber Intakes in Men

<table>
<thead>
<tr>
<th>Quintiles of Change in Dietary Exposure</th>
<th>Q1</th>
<th>Q5</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Weight Change (kg)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Added bran</td>
<td>1.16</td>
<td>1.0</td>
<td>0.01</td>
</tr>
<tr>
<td>Added germ</td>
<td>1.01</td>
<td>0.73</td>
<td>NS</td>
</tr>
<tr>
<td>Dietary fiber</td>
<td>1.40</td>
<td>0.39</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Adjusted for age, baseline exposure, smoking, baseline weight, baseline values and changes in refined grains, total energy, physical activity, alcohol, protein and trans, saturated, monounsaturated, polyunsaturated fats (all as % of total energy)

Presentation Outline

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- Gaps in the Knowledge
Obese adults (25 M, 25 F) with metabolic syndrome were randomly assigned to receive dietary advice either to **avoid** whole-grain foods or to obtain all of their grain servings from whole grains for 12 wk.

All participants were given the same dietary advice in other respects for weight loss i.e.

- 5 servings fruits and vegetables, 3 servings of low-fat dairy products, 2 servings lean meat, fish or poultry
Effects of a Whole Grain Enriched Hypocaloric Diet on Measures of Body Composition in Adults with Metabolic Syndrome

- Significant ↓
  - Body weight
  - Waist circumference
  - % Body fat (BF)
- ↓ Abdominal BF (%) was significantly ($P = 0.03$) greater in the whole-grain group than in the refined-grain group
- Greater emphasis on the avoidance of refined grains during whole-grain period

Katcher et al. (2008) Am J Clin Nutr 87;79-90
Maki et al. (2010)

- Randomized, parallel-arm, feeding study in 144 overweight and obese individuals in USA
- 12 weeks on a hypocaloric diet
  - 2 servings energy matched low-fiber foods (control)
  - 2 servings of WG RTE oat cereal
- No difference in weight loss
- Waist circumference decreased more with intervention vs control (-3.3 cm vs -1.9 cm)

No Change in Body Weight or Measures of Body Composition: Findings from the WHOLEheart Study

<table>
<thead>
<tr>
<th></th>
<th>8 weeks</th>
<th>16 weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (n=100)</td>
<td>Maintain current diet (Low WG)</td>
<td></td>
</tr>
<tr>
<td>Intervention 1 (n=85)</td>
<td>WG: ≈ 3 servings</td>
<td></td>
</tr>
<tr>
<td>Intervention 2 (n=81)</td>
<td>WG: ≈ 3 servings</td>
<td>≈ 6 servings</td>
</tr>
</tbody>
</table>

Observational Studies

Higher intake of whole grains linked with lower BMI, measures of abdominal adiposity and weight gain.

However...

- Marker of a healthier lifestyle
- Self reported diet
- Self reported body weight
Summary of Current Evidence

- Intervention Studies – evidence is inconsistent. *However*....
  - Compliance
  - Length of intervention period
  - Metabolically-at-risk individuals
Gaps in the Knowledge Base

- Few studies have examined the relationship between whole grain intake and abdominal adiposity or weight gain in ethnic minority groups, children or adolescents.

- Need for controlled metabolic studies, of longer duration, in both healthy and obese adults.

- Free-living intervention studies that incorporate biomarkers of intake in low whole grain grain consumers.
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Colleagues at Tufts....
Paul Jacques, Sc.D
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Thank you for your attention!