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Vegetable rich food pattern and health outcomes among Chinese adults
Overview

• Diet – disease association is widely studied, but often focuses on:
  o Single nutrient
  o Single food

• Overall diet is of interest: interaction between nutrients and foods; cumulative effects
Identification of dietary patterns

• Knowledge based
  o Healthy Eating Index

• Data driven methods
  o Factor analysis
  o Cluster analysis
  o Reduced Rank Regression
  o Method review by Newby et al

Dietary patterns and health outcomes
- findings from a Chinese cohort study

- Dietary patterns and ...
  - Obesity, weight gain
  - Sleep
  - Mortality
Jiangsu Nutrition Study - JIN

• Based on 2002 Chinese National Nutrition Survey
  o 6 counties, 2 cities
• Five year follow-up in 2007, two new regions joined
• 2012, mortality survey
• Run by Jiangsu Provincial Center for Disease Control and Prevention
• Funding:
  o Jiangsu Provincial Nature Science Foundation
  o Jiangsu Health Bureau
  o International Glutamic Technical Committee
  o The University of Adelaide
Background - study area

Area: ~ 0.1 million square km
Population: 73.55 million - density: 700 persons/square km (highest in China)
13 cities, 56 counties
Per capita GDP: 9,344 Yuan
Life expectancy at birth: Males 70 years; Females 75 years

Jiangsu contributes 10% of Chinese GDP!
Study sites

- Data collection run by Jiangsu Provincial Center for Disease Control and Prevention, and local CDCs.
- Funding support - Jiangsu CDC
Methods - Jiangsu Nutrition Study dataset

• 2002 national survey on nutrition and health
  o Nationwide, 31 provinces

• 5 year follow up in 2007
  o Only province in China – did follow up survey

• Household based

• Interview conducted by health workers

• 6 counties and 2 cities

• 20 years and above at baseline
Study sample (overall)

2002: 13,694 registered during household visit

3319 aged < 20 yrs

10,375

1049 did not answer questionnaire

9326

2012: 540 died (CVD 211, cancer 175)
Study sample (nutrition subset)

2002: 2849 had nutrient data

2007: 1682 were identified

1429 attended survey

1282 measured weight, height

Dropouts:
- Migrated to city for work
- Moved out of the original street, village
Measurements

• In 2002, baseline data collected by health workers
  o Height, weight, waist circumference, Hb
  o Sociodemographic information
  o Dietary information
    • FFQ (validated) - 33 food groups
    • 3 day weighted food record: nutrient intake

• In 2007, follow-up data collected
  o Height, weight, waist circumference, Hb
  o Diet - FFQ, but not weighted food record*

• In 2012, death survey (household visit, CDC death records)
Factor analysis

• 25 food groups (8 groups merged)
• Principal component analysis method
• Varimax rotation - for explanation
• Tried 2-8 common factors solutions
  o Finally chose 4 common factors solution
  o Easy/can be interpreted
Factor loadings

Macho

Traditional

-1 -0.5 0 0.5 1

Factor loading

Rice
Fresh vegetables
Pork
Fish
Pickled vegetable
Milk
Fruits
Liver
Poultry
Wine
Milk powder
Cake
Cheese
Yoghurt
Juice
Dry bean
Eggs
Beef, lamb
Beverage
Alcohol
Tofu
Deep-fried products
Whole grains
Beer
Nuts
Root vegetables
Wheat flour

-1 -0.5 0 0.5 1

Factor loading

Rice
Fresh vegetables
Pork
Fish
Pickled vegetable
Milk
Fruits
Liver
Poultry
Wine
Milk powder
Cake
Cheese
Yoghurt
Juice
Dry bean
Eggs
Beef, lamb
Beverage
Alcohol
Tofu
Deep-fried products
Whole grains
Beer
Nuts
Root vegetables
Wheat flour
Factor loadings

Sweet tooth

Vegetable rich

-4 -2 0 .2 .4 .6
Factor loading

-2 0 .2 .4 .6
Factor loading
Marginal mean intake of vegetable by quartiles of dietary pattern
Vegetable rich pattern and obesity (cross-sectional association)

<table>
<thead>
<tr>
<th>Intake of vegetable-rich food pattern quartiles</th>
<th>P for trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1 (low) Q2 Q3 Q4 (high)</td>
<td></td>
</tr>
<tr>
<td>General obesity(^a)</td>
<td></td>
</tr>
<tr>
<td>Men ((n=1308))</td>
<td>5.9  7.3  7.7 11.3</td>
</tr>
<tr>
<td>Women ((n=1541))</td>
<td>8.0 12.1 11.9 18.0</td>
</tr>
<tr>
<td>All</td>
<td>6.9  9.9 10.1 15.0</td>
</tr>
<tr>
<td>Central obesity(^b)</td>
<td></td>
</tr>
<tr>
<td>Men ((n=1308))</td>
<td>15.6 18.8 20.3 23.8</td>
</tr>
<tr>
<td>Women ((n=1541))</td>
<td>35.2 36.8 36.7 43.8</td>
</tr>
<tr>
<td>All</td>
<td>25.3 28.4 29.9 34.8</td>
</tr>
</tbody>
</table>

Abbreviation: Q, quartile. \(^a\)General obesity was defined as body mass index (BMI) \(\geq 28\) kg m\(^{-2}\), BMI is calculated as weight in kilograms divided by the square of the height in meters. \(^b\)Central obesity was defined as waist circumference \(\geq 90\) cm for men or \(\geq 80\) for women.

# Vegetable rich pattern and obesity (cross-sectional association)

<table>
<thead>
<tr>
<th></th>
<th>Quartiles of vegetable rich pattern</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Q1</strong></td>
<td><strong>Q2</strong></td>
</tr>
<tr>
<td><strong>General obesity</strong></td>
<td>1</td>
<td>1.54 (1.07-2.21)</td>
</tr>
<tr>
<td><strong>Central obesity</strong></td>
<td>1</td>
<td>1.14 (0.96-1.35)</td>
</tr>
</tbody>
</table>

*Odds ratio (95%CI)*

Dietary patterns and 5-year weight change

Vegetable oil intake in association to vegetable intake
Food intake by quartiles of vegetable rich pattern

- **Fruit**
- **Meat**
- **Rice**
- **Wheat**
## Rice intake and 5-year weight change

<table>
<thead>
<tr>
<th>Rice intake groups (g/d)</th>
<th>p</th>
<th>PRS*</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>201-400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;=401</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Age, sex adjusted**

<table>
<thead>
<tr>
<th>Rice intake groups (g/d)</th>
<th>p</th>
<th>PRS*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ref</td>
<td>-0.82 (-1.46, -0.17)</td>
<td>-0.27 (-0.35, -0.19)</td>
</tr>
<tr>
<td>201-400</td>
<td>-2.00 (-2.65, -1.36)</td>
<td></td>
</tr>
<tr>
<td>&gt;=401</td>
<td>&lt;0.001</td>
<td></td>
</tr>
</tbody>
</table>

**Multivariable adjusted**

<table>
<thead>
<tr>
<th>Rice intake groups (g/d)</th>
<th>p</th>
<th>PRS*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ref</td>
<td>-0.81 (-1.47, -0.15)</td>
<td>-0.28 (-0.37, -0.19)</td>
</tr>
<tr>
<td>201-400</td>
<td>-2.08 (-2.75, -1.41)</td>
<td></td>
</tr>
<tr>
<td>&gt;=401</td>
<td>&lt;0.001</td>
<td></td>
</tr>
</tbody>
</table>

*This column represents the amount of weight loss (kg) for every 10% increase in PRS (percentage of rice in staple foods)*

Fat intake and short sleep (cross-sectional)

Nutrient intake, blood profiles and sleep duration

<table>
<thead>
<tr>
<th>Sleep duration</th>
<th>&lt;7 h</th>
<th>7–9 h</th>
<th>9 or more hours</th>
<th>P-value$^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total energy intake (kJ)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>9483.5</td>
<td>9811.5</td>
<td>10130.3</td>
<td>0.002</td>
</tr>
<tr>
<td>s.e.</td>
<td>149.8</td>
<td>60.7</td>
<td>114.6</td>
<td></td>
</tr>
<tr>
<td><strong>Fat intake (g day$^{-1}$)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>84.39</td>
<td>80.96</td>
<td>77.73</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>s.e.</td>
<td>2.02</td>
<td>0.82</td>
<td>1.54</td>
<td></td>
</tr>
<tr>
<td><strong>Fat energy (% of total energy intake)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>33.84</td>
<td>31.23</td>
<td>28.86</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>s.e.</td>
<td>0.53</td>
<td>0.21</td>
<td>0.40</td>
<td></td>
</tr>
</tbody>
</table>

Fat intake and sleep duration

<table>
<thead>
<tr>
<th>Fat intake quartiles</th>
<th>Coefficient</th>
<th>P-value</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quartile 1</td>
<td>Reference</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quartile 2</td>
<td>-0.053</td>
<td>0.379</td>
<td>-0.170</td>
</tr>
<tr>
<td>Quartile 3</td>
<td>-0.077</td>
<td>0.229</td>
<td>-0.203</td>
</tr>
<tr>
<td>Quartile 4</td>
<td>-0.143</td>
<td>0.062</td>
<td>-0.293</td>
</tr>
<tr>
<td>Age (per year increase)</td>
<td>-0.014</td>
<td>0.000</td>
<td>-0.017</td>
</tr>
<tr>
<td>Female</td>
<td>0.029</td>
<td>0.617</td>
<td>-0.085</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Smoking per day (ref = none)</th>
<th>Coefficient</th>
<th>P-value</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1–19 cigarettes</td>
<td>-0.040</td>
<td>0.572</td>
<td>-0.177</td>
</tr>
<tr>
<td>20 or more cigarettes</td>
<td>-0.236</td>
<td>0.001</td>
<td>-0.377</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Alcohol consumption per week (ref = none)</th>
<th>Coefficient</th>
<th>P-value</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1–2 times</td>
<td>0.118</td>
<td>0.149</td>
<td>-0.042</td>
</tr>
<tr>
<td>3–4 times</td>
<td>0.049</td>
<td>0.634</td>
<td>-0.152</td>
</tr>
<tr>
<td>More than 4 times</td>
<td>-0.027</td>
<td>0.696</td>
<td>-0.163</td>
</tr>
</tbody>
</table>

Macronutrients intake by eating occasions and persistent short sleep (baseline + follow-up)

Unpublished data
MSG intake and sleep disordered breathing (SDB)

Dietary patterns and sleep disordered breathing (follow-up)

• Vegetable rich pattern inversely related to SDB
• Association was attenuated after adjustment for MSG intake.

Unpublished data
MSG intake by vegetable rich pattern

No association between other dietary patterns and MSG intake
BMI and mortality

Unpublished data
Dietary patterns and mortality

Unpublished data
Conclusion

• Vegetable rich food pattern
  o Positively associated with obesity and weight gain
  o Could be due to high vegetable oil intake, or high wheat/low rice
  o Inversely related to sleep distorted breathing
  o Inversely related to mortality

• Overall dietary pattern is important
  o Gives direction for diet-disease association: single food level

• Promoting vegetable intake should take culture into account: cooking method is important
  o In China, vegetable is often stir-fried with oil

• Eating occasion is important but less studied
Acknowledgement - collaborators

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University of Oslo
Prof Gerd Holmboe-Ottesen

University of Newcastle
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