Health and nutritional trends – obesity, nutritional profiling and the omega-3 and omega-6 fatty acid balance

Tom Sanders
Professor of Nutrition & Dietetics
Nutritional Sciences Research Division
King’s College London
- Fat quantity – obesity
- Fat quality – cardiovascular disease
Obesity Trends* Among U.S. Adults
(*BMI ≥30, or about 30 lbs overweight for 5’4” person)

1991

1996

2003

No Data
<10 10%-14% 15%-19% 20%-24% ≥ 25%

Source: Behavioral Risk Factor Surveillance System, CDC.
• Storing fat in the wrong place

• Metabolic syndrome
Fat patterning associated with metabolic syndrome
Coronary Heart Disease

- High LDL-C
- Metabolic Syndrome
- Type 2 Diabetes

Coronary Heart Disease
Relative Risk of Diabetes with increasing BMI
Obesity and metabolic syndrome

• Obesity contributes to causing metabolic syndrome

• Physical activity is protective

• A diet high in rapidly absorbed carbohydrate (both starch and sugar) makes metabolic syndrome worse
Figure 1 Numbers of people with diabetes (in millions) for 2000 and 2010 (top and middle values, respectively), and the percentage increase. Data adapted from ref. 2.
Energy Balance = Intake - Expenditure

- Energy intake (food)
- Energy expenditure (metabolism, activity)
- Weight change
Is obesity a genetic disorder?

- Precocious obesity under the age of 5 usually has a genetic cause.

- Common obesity in teenagers and adults is life-style acquired.
Leptin Therapy: From mice to humans

Left: Ob mouse 6 weeks post leptin therapy
Right: Ob mouse 6 weeks post saline injections

A child with a mutation in the leptin gene before and after leptin therapy


Causes of common obesity

- Access to high energy density food
- Low levels of physical activity
Energy density (ED) = kcal/100g

- a major factor in appetite control
- diets based on lower ED foods -> less weight gain risk

Diet ED <150 kcal/100g appears desirable for weight control

- Leafy vegetables
- Boiled potato
- Chicken
- Lamb
- Bread
- Sausages
- Chocolate
- Peanuts
- French fries
- Boiled sweets
- Hamburger
- Boiled rice
- Boiled pasta
- Cod baked
- Chicken
- Chapatis
- Salmon
- Cornflakes
- Danish Pastry
- Biscuits
- Bombay mix
- Margarine/Butter
- Brazil nuts
- Vegetable oil
- High water (fruit & veg)
- Moist, Hi pro (Mixed meals)
- Moist, Hi CHO
- Dry, high fat
- Dry, high CHO
Effect of fat additions on energy density

- Chapati made with fat
- Chapatis made without fat
- Chicken fried
- Chicken
- Fried rice
- Boiled rice
- Cod fried in batter
- Cod baked
- French fries
- Boiled potato

kcal/100g
What goes into crisps goes into you.
Total fat consumption has not increased during the obesity epidemic.

Per capita fat consumption in the UK

Source: UK Nation Food Survey
## National Dietary and Nutritional Survey

<table>
<thead>
<tr>
<th></th>
<th>Men</th>
<th></th>
<th>Women</th>
<th></th>
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<tbody>
<tr>
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<td>1986/87</td>
<td>2000/01</td>
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<td>Energy (MJ)</td>
<td>10.3</td>
<td>9.72</td>
<td>7.05</td>
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<td>Fat % food energy</td>
<td>40.4</td>
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<td>SFA</td>
<td>16.5</td>
<td>13.4</td>
<td>17</td>
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<td>Trans</td>
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<td>PUFA</td>
<td>6.2</td>
<td>6.4</td>
<td>6.1</td>
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</table>
The fat gap

• Obesity is rapidly increasing globally

• No evidence from N America or Europe to show fat intakes are increasing (the opposite is true)

• But vegetable oil production has increased markedly
High skill base, time consuming, “food” focused

Scratch Cooking
- e.g. primary products, traditional grocery

Component Cooking
- e.g. prepared vegetables, prepared meat/fish, sauces, pizza

Ready Meals

Take-Aways
- e.g. prepared vegetables, prepared meat/fish, sauces, pizza

Snacking ‘On the hoof’
- e.g. Sandwiches, Sushi

Delivery
QSR
Restaurant

Physical activity

Physical inactivity

Slow Food

Fast Food

Convenient social

© Worldpanel™ division of TNS 2003
Decreased Physical Activity

Television viewing

Weight gain

Increased Snacking

Increased Snacking

Decreased Physical Activity
Quality of fat

All-cis unsaturated fatty acids

Saturated fatty acids lauric, myristic and palmitic

Trans fatty acids
Types of Fatty Acid

- Saturated
- Monounsaturated
- Polyunsaturated
Non-essential

18:0  
Stearic  
Methyl group  
Carbon chain  
Carboxyl group

18:1n-9  
Oleic  
Methyl group  
Carboxyl group

Essential

18:2n-6  
Linoleic  
Animals can insert double bonds here  
but not here

18:3n-3  
α-Linolenic
<table>
<thead>
<tr>
<th>Dietary source</th>
<th>n-6 series</th>
<th>n-3 series</th>
<th>Dietary source</th>
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<tbody>
<tr>
<td>Vegetable oils</td>
<td>18:2n-6 Linoleic</td>
<td>18:3n-3 α-Linolenic</td>
<td>Vegetable oils</td>
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<td>↓</td>
<td>↓</td>
<td></td>
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<tr>
<td></td>
<td>18:3n-6 Gamma-linolenic</td>
<td>18:4n-3 Stearadonic</td>
<td></td>
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<tr>
<td></td>
<td>↓</td>
<td>↓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20:3n-6 Dihomogammaladinolenic</td>
<td>20:4n-3</td>
<td></td>
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<tr>
<td></td>
<td>↓</td>
<td>↓</td>
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<tr>
<td></td>
<td>20:4n-6 Arachidonic</td>
<td>20:5n-3</td>
<td>Fish oil</td>
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<tr>
<td>Fish, meat</td>
<td>Eicosapentaenoic</td>
<td>22:5n-3</td>
<td></td>
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<td></td>
<td>↓</td>
<td>↓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>22:6n-3 Docosahexaenoic</td>
<td>Fish oil, offal</td>
<td></td>
</tr>
</tbody>
</table>
Effect of partial hydrogenation

Cis monounsaturated  Trans Fatty Acid

Raises melting point and improves organoleptic properties
Effect of hydrogenation on rapeseed oil

- Saturates
- Monounsaturates
- Polyunsaturates
- Trans Fats

Unhydrogenated Partially hardened Hardened

(%)
The Heart Attack

1. Health coronary artery
2. Artery with atherosclerosis
3. Thrombosis
4. Myocardial infarction
Blood cholesterol as a risk factor for CHD

- Elevated LDL and low HDL cholesterol are involved in the atherogenic process
- Differences in saturated fatty acid intake explain 2/3rds of the variation in plasma LDL cholesterol between populations
- Intervention trials using drugs have shown
  - 1) that lowering LDL cholesterol decreases risk
  - 2) that increasing HDL decreases risk
Predicted changes in the ratio of serum total to HDL cholesterol and in LDL- and HDL-cholesterol concentrations when carbohydrates constituting 1% of energy are replaced by different fatty acids

Comparative effect of different plant derived fatty acids on LDL and HDL cholesterol

- Saturated fatty acids – (lauric, myristic and palmitic) raise LDL cholesterol
- Oleic acid – is neutral
- Linoleic acid and linolenic acids slightly lower LDL cholesterol
- Trans unsaturated fatty acids raise LDL cholesterol and lower HDL cholesterol
CARDIOVASCULAR MORTALITY IN EUROPE (WHO, 1995)

Age standardised death rate per 100,000 population

- France: 36
- Italy: 48
- Spain: 48
- Sweden: 50
- Belgium: 53
- Luxembourg: 54
- Netherlands: 54
- Portugal: 56
- Greece: 59
- Denmark: 60
- Germany: 64
- Austria: 67
- UNITED KINGDOM: 70
- Finland: 73
- Ireland: 86

Persons under age 65

Map showing countries with different mortality rates.
Relationship between serum cholesterol and CHD incidence in the Seven Countries Study and smoking (%)

United States: 6.19, 59%
Northern Europe: 6.51, 66.6%
Mediterranean Europe: 5.17, 59.2%
Inland Southern Europe: 5.28, 59.3%
Serbia: 4.24, 56.1%
Japan: 4.25, 74.5%
Changes in weekly oil and fats consumption in the UK 1992-2000
Death rates from CHD, stroke and all other diseases of the circulatory system, people aged under 75, 1970-1999, England, with Our Healthier Nation milestone and target.
Risk of CHD according to changes in the intakes of different fatty acids

Nurses Health Study
Risk of fatal CHD is decreased the intake long chain n-3 fatty acids and not affected by the ratio

Hu et al. JAMA 2002
Intake of long chain n-3 fatty acids in 41,578 Japanese men and women and risk of CHD over 10 years

Data from the Nurses Health Study suggests linoleic acid decreases risk of CHD
Hierarchy in Scientific Evidence

Level of Evidence

High

Low

Systematic Reviews (Meta-analysis)

Randomized Controlled Trials

Other Controlled Trials

Prospective Cohort studies

Case – Control studies

Prevalence studies

Ecological studies

Animal studies
The Women’s Health Initiative

- 48,835 postmenopausal women were randomized to dietary modification (40% or a comparison group (60%)
- Dietary fat intake was 8.1% energy lower at year 6
- The difference in weight between the control and intervention group after 8 years was only 1.3 kg
- The intervention had no significant effect on incidence of cancer, heart disease or diabetes

Howard, B. V. et al. JAMA 2006;295:655-666
Influence of decreasing fat or exchanging saturated fatty acids for polyunsaturated fatty acids on cardiovascular mortality
Hooper et al. *BMJ* 2001;322:757-763 (31 March)
Risks and benefits of omega 3 fats for mortality, cardiovascular disease, and cancer: systematic review
Review of studies published up to 2002

• **Results** The pooled estimate showed no strong evidence of reduced risk of total mortality (relative risk 0.87, 95% confidence interval 0.73 to 1.03) or combined cardiovascular events (0.95, 0.82 to 1.12) in participants taking additional omega 3 fats.

• **Conclusion** Long chain and shorter chain omega 3 fats do not have a clear effect on total mortality, combined cardiovascular events, or cancer.

Hooper et al. BMJ 2006 epub 24 March 2006
RCT data, marine omega 3 fats only

<table>
<thead>
<tr>
<th>Study</th>
<th>Events</th>
<th>Controls</th>
<th>OR</th>
<th>CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burr (DART) 1989</td>
<td>93/1015</td>
<td>131/1018</td>
<td>0.71</td>
<td>0.55 to 0.92</td>
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<tr>
<td>Kaul 1992</td>
<td>0/58</td>
<td>1/49</td>
<td>0.28</td>
<td>0.01 to 6.78</td>
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<tr>
<td>Leaf 1994</td>
<td>0/275</td>
<td>2/276</td>
<td>0.20</td>
<td>0.01 to 4.16</td>
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<tr>
<td>Stocks (HARP) 1996</td>
<td>0/41</td>
<td>1/39</td>
<td>0.32</td>
<td>0.01 to 7.57</td>
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<tr>
<td>Entslund 1996</td>
<td>8/317</td>
<td>6/293</td>
<td>1.23</td>
<td>0.43 to 3.51</td>
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<tr>
<td>Singh 1997</td>
<td>14/122</td>
<td>13/69</td>
<td>0.62</td>
<td>0.26 to 1.04</td>
</tr>
<tr>
<td>GISSI-P 1999</td>
<td>477/5665</td>
<td>554/5658</td>
<td>0.86</td>
<td>0.77 to 0.97</td>
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<tr>
<td>Johansen 1999A</td>
<td>1/280</td>
<td>3/280</td>
<td>0.33</td>
<td>0.03 to 3.18</td>
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<td>von Schacky 1999</td>
<td>1/112</td>
<td>2/111</td>
<td>0.50</td>
<td>0.05 to 5.39</td>
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<td>Brox 2001</td>
<td>0/80</td>
<td>1/40</td>
<td>0.17</td>
<td>0.01 to 4.06</td>
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<tr>
<td>Nielsen 2001</td>
<td>11/150</td>
<td>11/150</td>
<td>1.00</td>
<td>0.45 to 2.24</td>
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<tr>
<td>Burr 2003</td>
<td>283/1571</td>
<td>242/1543</td>
<td>1.15</td>
<td>0.98 to 1.34</td>
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<tr>
<td>Subtotal (95% CI)</td>
<td>9656</td>
<td>9486</td>
<td>0.86</td>
<td>0.70 to 1.04</td>
</tr>
</tbody>
</table>

Total events: 888 (high omega 3 fats), 957 (low omega 3/control)
Test for heterogeneity: $\chi^2=19.98$, df=11, $P=0.05$, $I^2=44.9\%$
Test for overall effect: $z=1.542$, $P=0.12$

RCT data, $\alpha$-linolenic acid only

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<tr>
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<th>OR</th>
<th>CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Borchgrevink 1966</td>
<td>10/100</td>
<td>14/100</td>
<td>0.71</td>
<td>0.33 to 1.53</td>
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<td>Natvig 1968</td>
<td>43/6715</td>
<td>40/6690</td>
<td>1.07</td>
<td>0.70 to 1.54</td>
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<tr>
<td>Singh 1997</td>
<td>16/120</td>
<td>13/69</td>
<td>0.61</td>
<td>0.31 to 1.17</td>
</tr>
<tr>
<td>Berentsmans 2002</td>
<td>3/109</td>
<td>1/157</td>
<td>4.32</td>
<td>0.46 to 41.00</td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td>7045</td>
<td>7006</td>
<td>0.87</td>
<td>0.57 to 1.34</td>
</tr>
</tbody>
</table>

Total events: 72 (high omega 3 fats), 58 (low omega 3/control)
Test for heterogeneity: $\chi^2=4.27$, df=3, $P=0.23$, $I^2=29.8\%$
Test for overall effect: $z=0.62$, $P=0.54$

Cohort data

<table>
<thead>
<tr>
<th>Study</th>
<th>Events</th>
<th>Controls</th>
<th>OR</th>
<th>CI</th>
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</thead>
<tbody>
<tr>
<td>Dolecek 1991</td>
<td>72/1251</td>
<td>99/1307</td>
<td>0.76</td>
<td>0.57 to 1.02</td>
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<tr>
<td>Erkkila 2003</td>
<td>5/132</td>
<td>16/133</td>
<td>0.31</td>
<td>0.12 to 0.83</td>
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<tr>
<td>Hu 2003</td>
<td>49/491</td>
<td>77/487</td>
<td>0.63</td>
<td>0.45 to 0.88</td>
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<tr>
<td>Subtotal (95% CI)</td>
<td>1874</td>
<td>1927</td>
<td>0.65</td>
<td>0.48 to 0.88</td>
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</tbody>
</table>

Total events: 125 (high omega 3 fats), 192 (low omega 3/control)
Test for heterogeneity: $\chi^2=3.13$, df=2, $P=0.21$, $I^2=36.1\%$
Test for overall effect: $z=2.81$, $P=0.005$
Fat and heart disease

• Decreasing the intake of fat has not been shown to reduce risk of heart disease

• But changing the type of fat consumed probably reduces risk of heart disease.
  – Replacing saturated and trans fatty acids with unsaturated fatty acids
  – Increasing the intake of n-3 fatty acids
  – Increasing the intake of linoleic acid
Conclusion

• Fat needs to be consumed in moderation to avoid obesity

• Attention needs to be paid to the fatty acid profile in order to prevent cardiovascular disease
Nutrient Profiling

- A scheme developed by the UK Food Standards Agency to classify foods into “good” and “bad” categories is now spreading to other countries.
- To be used as a management tool:
  - To provide front of pack labelling
  - To regulate TV advertising of food targeted at children
  - To control the types of food that can be used to make up school meals
  - To regulate health claims
High Fat is >20g/100g
High Sat Fat >5g/100g

Using this definition all oils would fall into the high category
Ideal fatty acid profile of vegetable oil

- <15% saturated fatty acids
- 15% polyunsaturated fatty acids
  - n-6/n-3 ratio <10:1
- 70% monounsaturated
- Trans <1%