Cardiovascular benefits of eating oats: evidence explained and mechanisms explored

Dr Frank Thies
CVD: main cause of mortality in Western countries. Rate in Scotland is amongst the highest in Europe and worldwide.

All ages yearly mortality in Scotland:

- Coronary heart disease 9,343
- Stroke 5,333
- Other CVD 3,903

Total CVD: 18,600
CARDIOVASCULAR DISEASE: WHAT IS IT?

- Ischemic heart disease
- Cerebrovascular disease
- Peripheral vascular disease

Major underlying cause: **atherosclerosis**
Schematic Time Course of Human Atherogenesis

Lesion initiation

No symptoms

± Symptoms

Time (y)

Symptoms

Ischemic Heart Disease

Cerebrovascular Disease

Peripheral Vascular Disease
Development of Atherosclerotic Plaques

- Normal
- Fatty streak
- Foam cells
- Lipid-rich plaque
- Fibrous cap
- Thrombus
- Lipid core
Healthy

Diseased
Main risks factors for CVD

CVD

DIET
(Wholegrain? Oats?)

Obesity

Hypertension

Insulin resistance

Genetic

Alcohol

Smoking

Physical activity
WHOLE GRAINS IN HUMAN DIET

- Amaranth
- Barley
- Brown rice
- Buckwheat
- Bulgur
- Emmer/Farro
- Grano
- Kamut

- Millet
- Oatmeal and whole oats
- Popcorn
- Quinoa
- Sorghum
- Spelt
- Teff

- Triticale
- Whole corn
- Wholegrain pasta
- Whole rye
- Whole wheat
- Whole wheat couscous
- Wild rice
• In the UK, wholegrain foods are comprised mainly of wheat & to a lesser extent oats.

• Soluble fibre content & the composition of micronutrients, fatty acids and other phytochemicals differs between grains.
“outer shell” protects seed (fiber, B vit, trace minerals, phytochemicals)

Energy store, CHO, protein, some B vit

Antioxidants, vit E. B vit, trace minerals, phytochemicals, lipids
Milling

Removal of bran and germ layers: Enhance desirability, improve texture, flavour, Appearance, Increase shelf life

However, loss of vitamins, minerals, phenolics, fiber
What’s lost when whole grains are refined? This graph shows how much of 15 nutrients in whole wheat flour is left after it’s milled into enriched white flour.

- Vitamin E
- Vitamin B-6
- Magnesium
- Manganese
- Fiber
- Zinc
- Potassium
- Copper
- Pantothenic Acid
- Folate
- Protein
- Niacin*
- Iron*
- Thiamin*
- Riboflavin*

* = This nutrient has been added to enriched white flour.

|= Enriched white flour.
High consumption of wholegrain food is associated with reduced risk of CVD and type2 diabetes

**ARIC study (15,792 men and women)** Steffen et al, 2003

3 servings/day → 28% decrease risk of CAD

**Iowa Women Health Study (30,000 women)** Jacob et al, 1999

≥ 1 serving/day → 23% decrease risk of IHD

**Harvard Nurses’ Health Study (75,000 women)** Liu et al, 1999

≈ 3 servings/day → 21% decrease risk of CHD

**Health Professional Follow-UP (42,850 women)** Jensen et al, 2004

≈ 3 servings/day → 18% decrease risk of CHD
POTENTIAL MECHANISMS

WHEAT-BASED FOOD

- Lower plasma TAG?
- Insulin sensitivity?
- Endothelial function?
- Arterial stiffness?
- Inflammatory markers?
- Hyperhomocysteinemia?
- Hypertension?
- Gut microbiota?

OATS

- Lower plasma cholesterol?
Oats and CVD risk markers: a systematic literature review

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CVD risk markers considered

LIPIDS
- Lipid (total cholesterol)
- LDL cholesterol
- HDL cholesterol
- TC:HDL chol
- HDL subfractions
- IDL
- VLDL
- Lipoprotein size

BLOOD PRESSURE

INSULIN RESISTANCE

OTHERS
- Inflammatory markers
- Lp(a)
- Endothelial function
- Homocysteine
- Coagulation factors
Results from literature search on randomised controlled trial with oat products and CVD markers

76 relevant articles

69 studies

- <30 subjects: 41 studies (59%)
- 30 – 59 subjects: 17 studies (25%)
- >60 subjects: 11 studies (16%)

Only 39% of high quality of reporting
54% carried out in North America (USA and Canada)
RESULTS

BLOOD LIPIDS:

- Beneficial effect on blood cholesterol (3-6% and 4-8% decrease for total and LDL cholesterol respectively)

- Support data from observational studies

- Confirm supplementation studies with soluble fibre.

- Particularly beneficial in people with high cholesterol

- Would translate to a 6-18% decreased risk of coronary heart disease.

- No apparent significant effects on other lipids
Fasting glucose/insulin and insulin sensitivity:

No apparent effects of increased oat consumption

Other markers:

No effects on inflammatory markers or markers of vascular health, but limited number of studies.

Few studies measured coagulation factors (fibrinogen, factor VII, PAI-1) and found beneficial effects. More work required !!!
BLOOD PRESSURE:

- Few studies found positive outcome
- However studies too small
- Wrong method usually used!

Previous work using wholegrain (wheat or wheat + oats) found significant effect

Adequately powered and controlled intervention trials required!!!!

Tighe P. et al, AJCN 2010
Whole-grain and blood lipid changes in apparently healthy adults: a systematic review and meta-analysis of randomized controlled studies

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AJCN doi: 10.3945/ajcn.115.109165
Meta-analysis of change in LDL cholesterol (mmol/L) from oat-based interventions

Chang 2013 (32) 3.8%  -0.33 [-0.59, -0.07]
Davidson (56g) (21) 0.7%  -0.23 [-0.95, 0.49]
Davidson (84g) (21) 0.5%  -0.58 [-1.39, 0.23]
Davidson 1991 (20g) (21) 0.7%  -0.33 [-1.02, 0.36]
Johnston 1998 (30) 8.0%  -0.18 [-0.30, -0.06]
Karmally 2005 (31) 6.7%  -0.27 [-0.43, -0.11]
Maki 2010 (10) 10.1%  -0.11 [-0.16, -0.04]
Saltzman 2001 (11) 4.0%  -0.40 [-0.65, -0.15]
Van Horn 1988 (High TC) (29) 6.0%  -0.05 [-0.23, 0.13]
Van Horn 1988 (Low TC) (29) 6.2%  -0.04 [-0.21, 0.13]
Van Horn 1981 (25) 2.4%  -0.25 [-0.60, 0.10]
Subtotal (95% CI) 49.1%  -0.17 [-0.25, -0.10]

Heterogeneity: Tau² = 0.00; Chi² = 14.15, df = 10 (P = 0.17); I² = 29%
Test for overall effect: Z = 4.80 (P < 0.00001)
Meta-analysis of change in total cholesterol (mmol/L) from oat-based interventions

<table>
<thead>
<tr>
<th>Study</th>
<th>% Change</th>
<th>Effect Size (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chang 2013 (32)</td>
<td>3.6%</td>
<td>-0.41 [-0.72, -0.10]</td>
</tr>
<tr>
<td>Davidson (56g) (21)</td>
<td>0.7%</td>
<td>-0.23 [-1.05, 0.59]</td>
</tr>
<tr>
<td>Davidson (84g) (21)</td>
<td>0.6%</td>
<td>-0.57 [-1.47, 0.33]</td>
</tr>
<tr>
<td>Davidson 1991 (28g) (21)</td>
<td>0.7%</td>
<td>-0.30 [-1.10, 0.50]</td>
</tr>
<tr>
<td>Johnston 1998 (30)</td>
<td>8.3%</td>
<td>-0.23 [-0.36, -0.10]</td>
</tr>
<tr>
<td>Karmally 2005 (31)</td>
<td>7.2%</td>
<td>-0.31 [-0.48, -0.14]</td>
</tr>
<tr>
<td>Maki 2010 (10)</td>
<td>10.9%</td>
<td>-0.07 [-0.13, 0.00]</td>
</tr>
<tr>
<td>Saltzman 2001 (11)</td>
<td>3.9%</td>
<td>-0.53 [-0.82, -0.24]</td>
</tr>
<tr>
<td>Van Horn 1988 (High TC) (29)</td>
<td>7.2%</td>
<td>-0.17 [-0.33, -0.01]</td>
</tr>
<tr>
<td>Van Horn 1988 (Low TC) (29)</td>
<td>7.6%</td>
<td>0.00 [-0.15, 0.15]</td>
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<td>Van Horn 1991 (25)</td>
<td>2.7%</td>
<td>-0.32 [-0.69, 0.05]</td>
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<td>Subtotal (95% CI)</td>
<td>53.2%</td>
<td>-0.22 [-0.32, -0.11]</td>
</tr>
</tbody>
</table>

Heterogeneity: \( \tau^2 = 0.01; \chi^2 = 26.13, df = 10 (P = 0.004); I^2 = 62\% \)
Test for overall effect: \( Z = 4.07 \) (\( P < 0.0001 \))
SUMMARY

Health benefit of increased oats consumption

- Reduce “bad” cholesterol
- Potentially reduce blood pressure
- No apparent effect on insulin resistance/sensitivity
- Further work required for other markers
Beneficial Effects of Oats Against CVD: Potential Mechanisms

- Satiety
- Weight Management
- Insulin Sensitivity
- Hypertension
- Lower Plasma Cholesterol
- Inflammation
- Immune function
- Endothelial Function Arterial Stiffness
Involvement of gut microbiota?

- **Physical barrier**
  - Reduced area for lipase action
  - Reduced lipid uptake

- **Beta-glucan**

- **Satiety**
  - Low GI - Glucose uptake

- **Soluble fibre (sponge)**
  - Decreased bile acid absorption, increases cholesterol mobilisation

- **Inflammatory mediators**

- **Gut microbiota**

- **GI hormones**

- **SCFA production**

Questions:
- Blood pressure?
- Lipogenesis?
- Colonocyte energy
- Gluconeogenesis?
SP project: Realizing the potential of cereal products to benefit human health

Staff involved

Karen Scott
Andrew Chappell
Lynsey Mills
Frank Thies

Derek Stewart
Gordon McDougal
Robbie Waugh
Bill Thomas
David Marshall

Claire Halpin
Miriam Schrieber

Peter Martin
Frank Thies
Objective 5 (K Scott/F Thies) to assess the health effects of increased consumption of oats compared to refined cereals on blood pressure, cholesterol, gut hormone secretion, gut microbiota composition.

Increasing consumption of oat products to 100g/day

Reduces cholesterol
Changes microbiota

E. rectale/Roseburia group

% butyrate

pH

Unpublished work by Karen Scott et al
Main study details

Refined diet N=60

Refined cereals diet (>100g/day) (N=30)
OR
High oat diet (>100g/day) (N=30)

Week -2
Screening
Information sheet
Eligibility screening
Study discussion
Consent form
Health questionnaire
4-day food diary

Week 0
Randomise

Week 4
Sampling
Fasted blood sample
kinetics
BMI
Blood pressure
Spot urine sample
Faecal sample

Gut hormone

8 x bloods over 3 hours
4-day food diary

Week 10

Week 16
Diets
At least 100 g per day of relevant cereal grain....

Control
- Refined cereals
- No wholegrain
- No oats or barley
- Pasta
- Rice
- Couscous

Oats
- Porridge
- Oatibix
- Enriched bread
- Oatcakes
- Oat milk
- Flapjack & biscuits

Barley
- Grapenut cereal
- Enriched bread, scones & muffins
- Scotch broth
- Casseroles & stews
- Couscous

At least 100 g per day of relevant cereal grain....

- Refined cereals
- No wholegrain
- No oats or barley
- Pasta
- Rice
- Couscous
Outcome measures

**General**
- Weight
- Blood pressure
- Compliance: Food diaries
- Plasma markers

**Plasma**
- Cholesterol
- Triglycerides
- NEFA
- Oxidised LDL
- Insulin
- Glucose

**Faeces**
- Bacterial profile – FISH
- Profile changes - DGGE
- SCFA production

**Urine**
- Lipoproteins, ApoA1 & B100
- Serum amyloid A
- hsCRP
- Isoprostanes
- Peptide YY
- Ghrelin
- GIP
- GLP-1

**Faeces**
- Mycotoxins

RESULTS AVAILABLE SOON!
Thank you!
Possible regulation of cholesterol homeostasis by SCFA

Rideout T et al 2008