Health Benefits of Whole Grains
The Newest Evidence

Food, Nutrition, and Health Update 2014

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Disclosures

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- Scientific Advisor for the Whole Grains Council
- All views expressed in this talk are my own

Presentation Roadmap

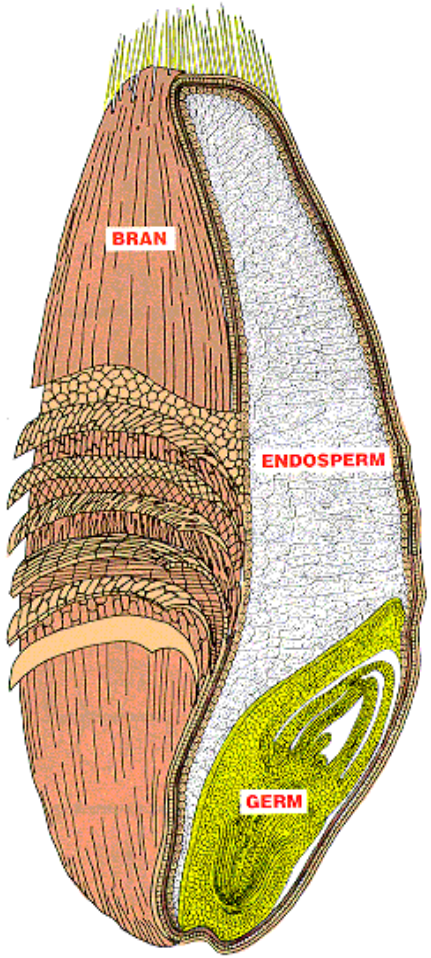
- Background
  - What is a whole grain?
  - Effect of processing
  - Current intakes
  - Potential health mechanisms
- Review of the scientific evidence
- Conclusions and practical recommendations

What is a Whole Grain?

- American Association of Cereal Chemists (AACC) International definition:

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

  This definition means that 100% of the original kernel – all of the bran, germ, and endosperm – must be present to qualify as a whole grain



- No universally accepted definition of a whole grain

Types of Whole Grains

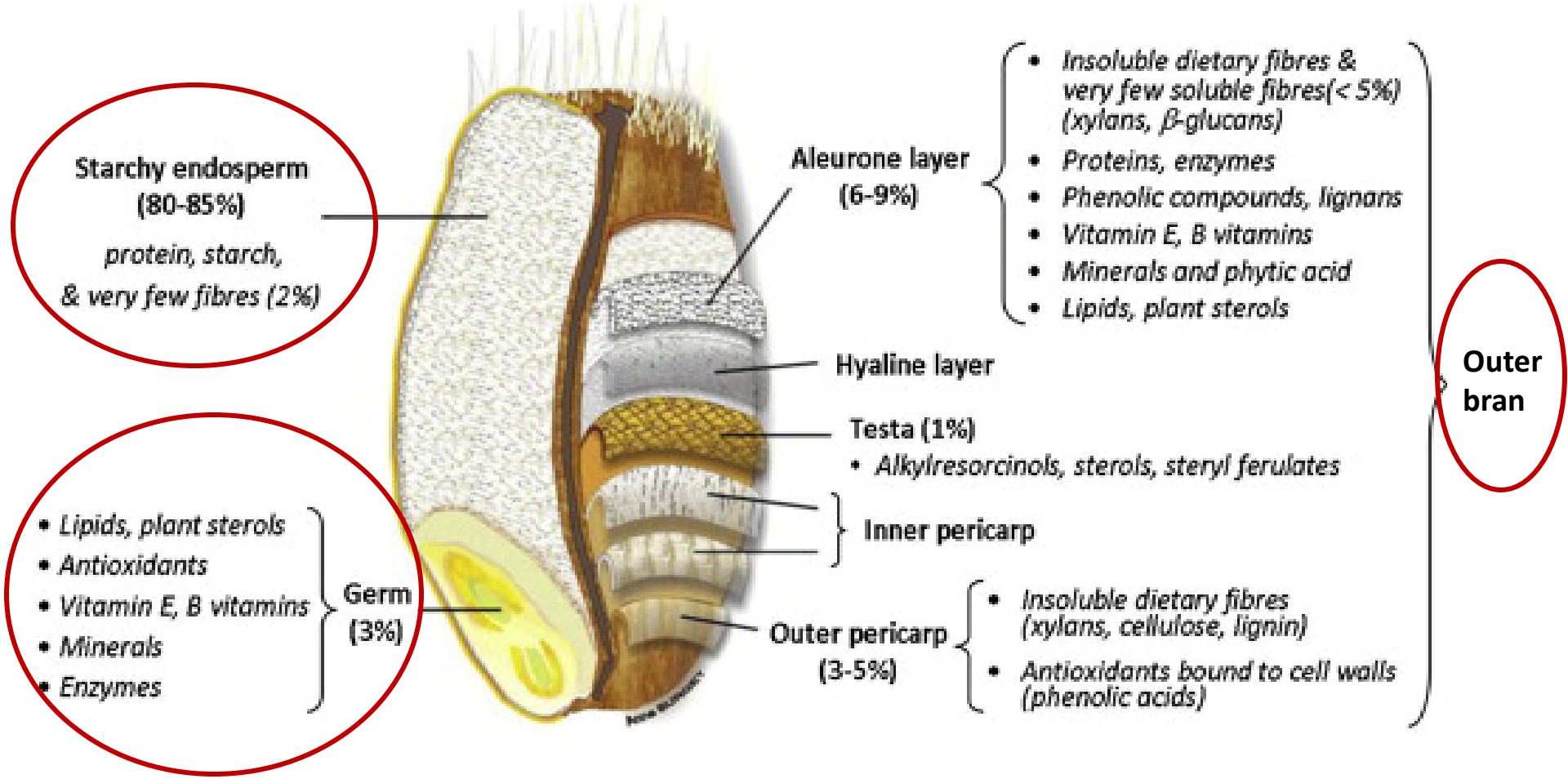
True Grains (*Poaceae* or *Gramineous* family)

- Wheat
  - (includes Spelt, Farro, Kamut,
  - Emmer, Durams, Einkorn)
- Oats
- Rice
- Corn (maize, popcorn)
- Barley (hulled)
- Rye
- Canary Seed
- Millet
- Wild rice
- Triticale
- Sorghum
- Teff
- Fonio
- Job's Tears

Pseudocereal Grains

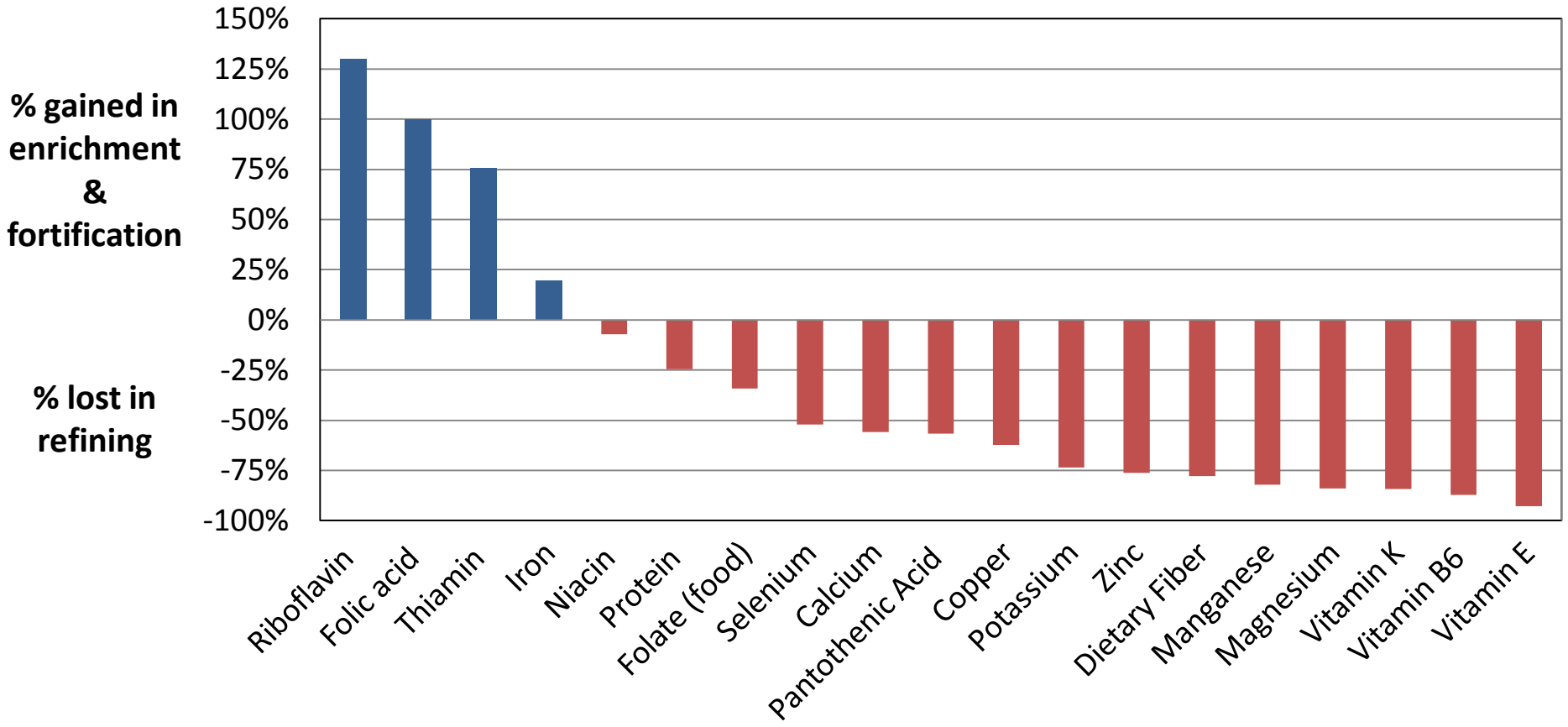
- Buckwheat
- Amaranth
- Quinoa

The Whole Grain Kernel



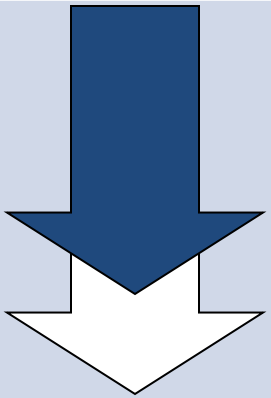
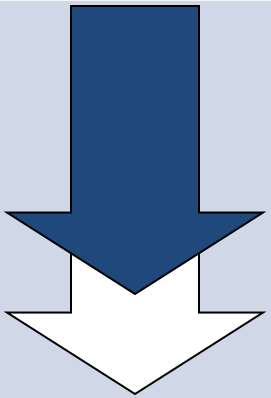
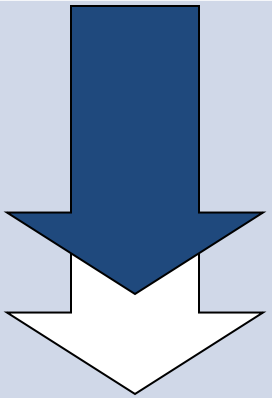
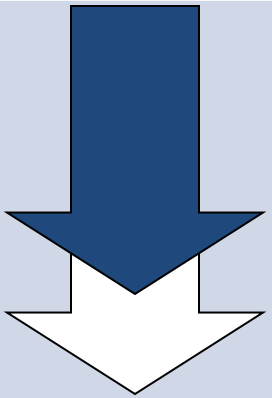
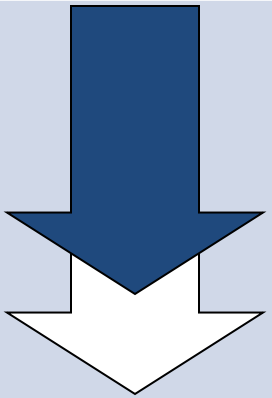
Brouns et al. (2013); Surget & Barron (2005)

Effects of Processing on the Grain (i.e. the removal of bran and germ)



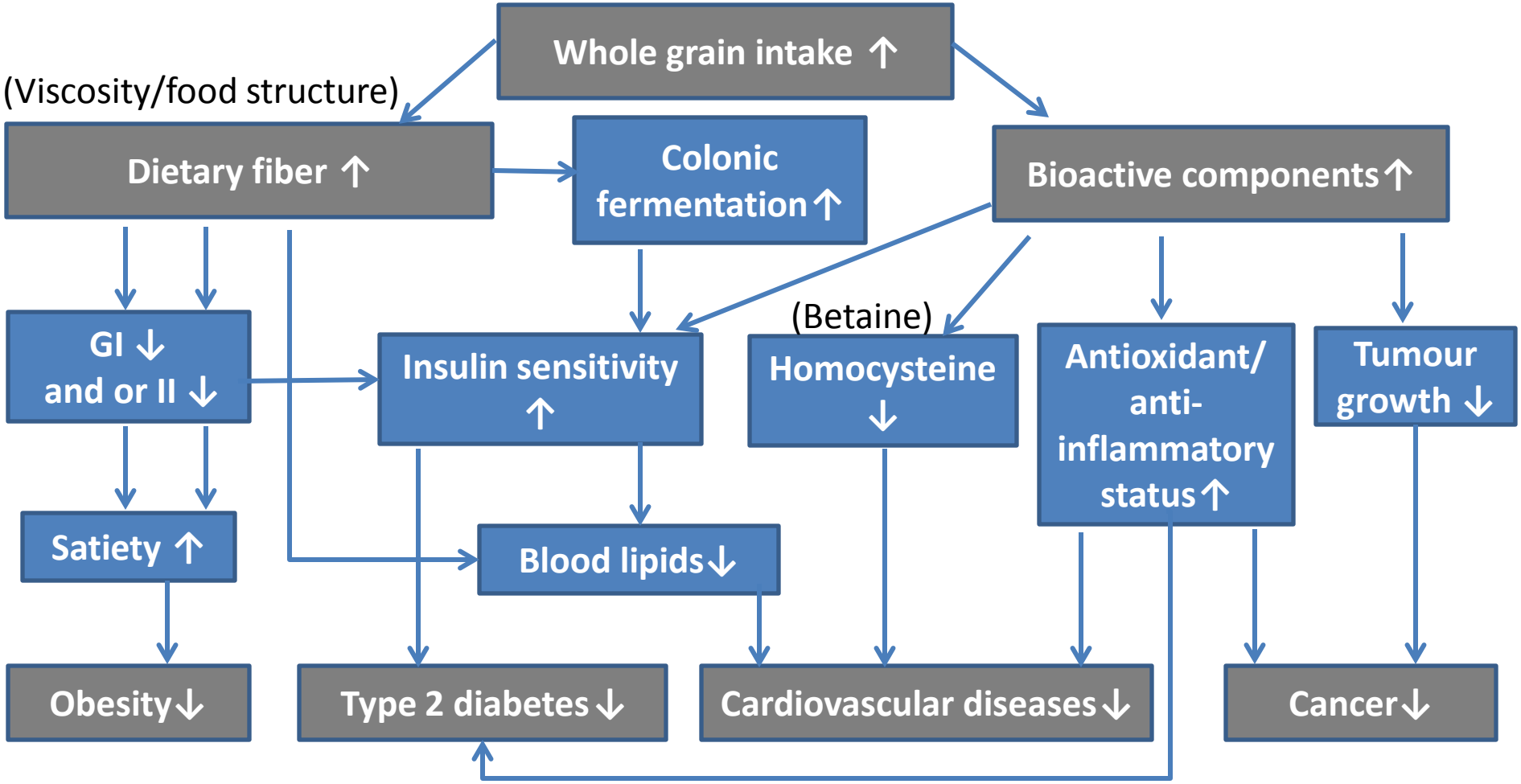
USDA National Nutrient Database for Standard Reference Release. http://www.nal.usda.gov/fnic/foodcomp/search

Health Benefits of Whole Grains

Cardiovascular Disease	Type 2 Diabetes	Weight Management	Colorectal Cancer	Blood Pressure
				
~21%↓	**~26% ↓**	**0.5 kg/m²↓**	**17% ↓**	**23%↓**

Ye, et al J Nutr (2012); Dagfinn et al. BMJ (2011)

Whole Grains and Chronic Disease Reduction: Potential Mechanism



Björck et al. Cereal grains for nutrition and health benefits: Overview of results from in vitro, animal and human studies in the HEALTHGRAIN project . *Trends in Food Science & Technology* 2012; 25(2): 87-100.

Whole Grain and Dietary Fiber Intakes in US Adults

	Whole Grains		Dietary Fiber	
Recommended Intake	At least half of all grains be consumed as whole grains		25 g/d women; 38 g/d men	
Current Intake	2009-2010: ~8%		2009 -2010: 14 g/d women 18 g/d men	

Reicks et al. 2014 Nutrition Research doi:10.1016/j.nutres.2014.01.002

Consumer Confusion over Whole Grains and Fiber

- 7 out of 10 consumers are trying to consume more fiber and whole-grains *
- Of consumers reporting they choose “whole grains” in an effort to get more fiber, 85% assumed the product was an excellent source of fiber **

REUTERS / *February 5, 2014, 1:55 PM*

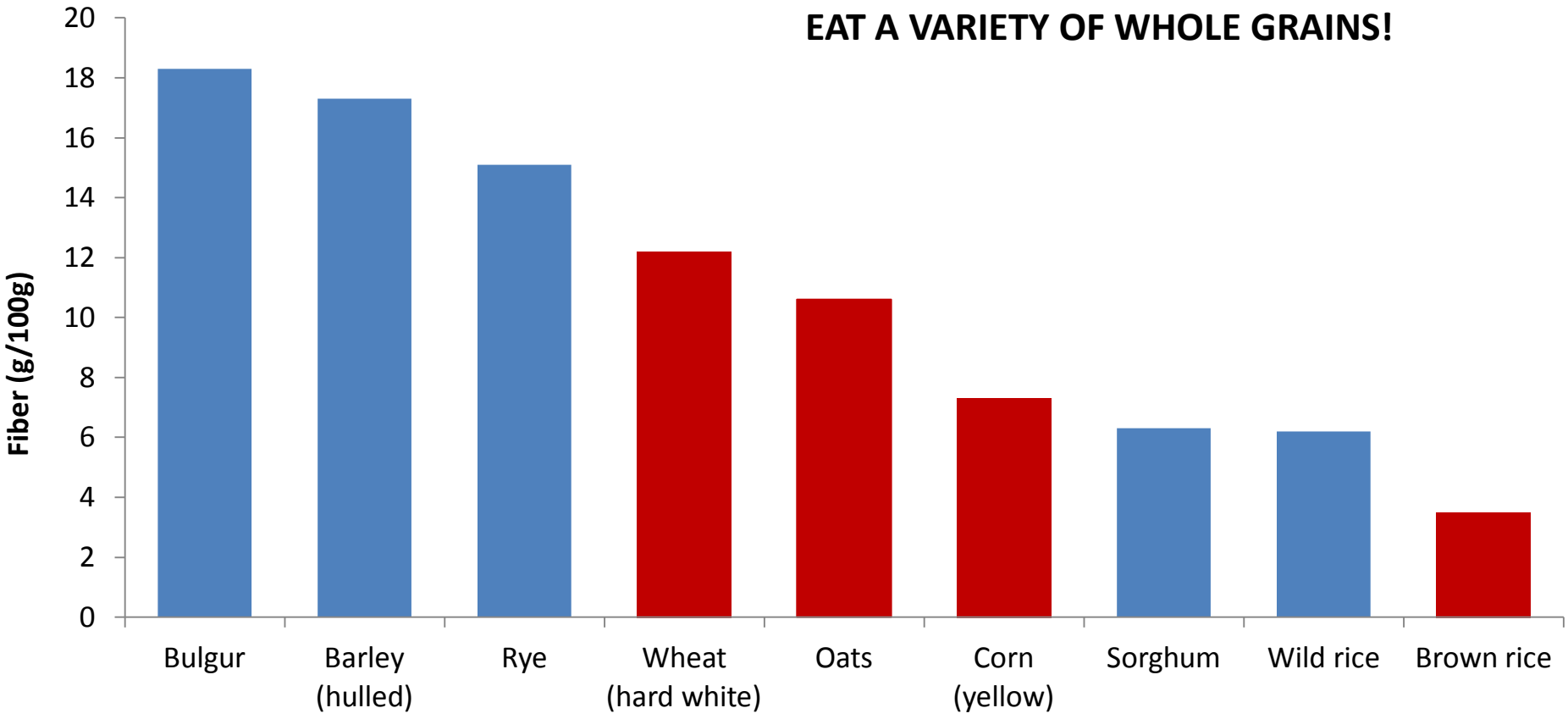
Most Americans don't eat enough whole grains, fiber: study

The self-service wholegrain containers at Unpackaged, an organic grocery shop, on Nov. 8, 2007 in London, England. / **CATE GILLON/GETTY IMAGES**

***2010 Food and Health Survey conducted by the International Food Information Council**

**** http://www.nutrition411.com/pdf_mar/Flip%20for%20Fiber.pdf**

Comparison of Fiber Content of Equivalent Amount of Whole Grains

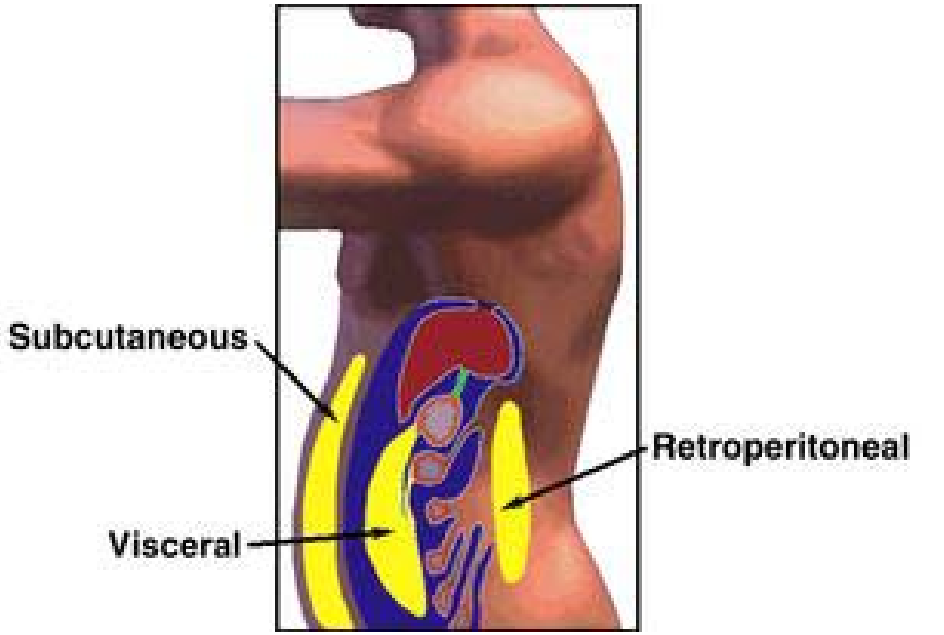


NDB. USDA Nutrient Database for Standard Reference. USDA Agricultural Research Service. http://ndb.nal.usda.gov/

Presentation Roadmap

- Background
- Review of the Scientific Evidence
  - Obesity
    - Gut microbiota
  - Surrogate risk factors for CVD
    - Glucose and Insulin Metabolism
    - Lipids
    - Blood Pressure
  - Cognition

Abdominal Obesity: The Critical Adipose Depot



↑ Insulin resistance

↑ Inflammation

↑Atherogenic dyslipidemic

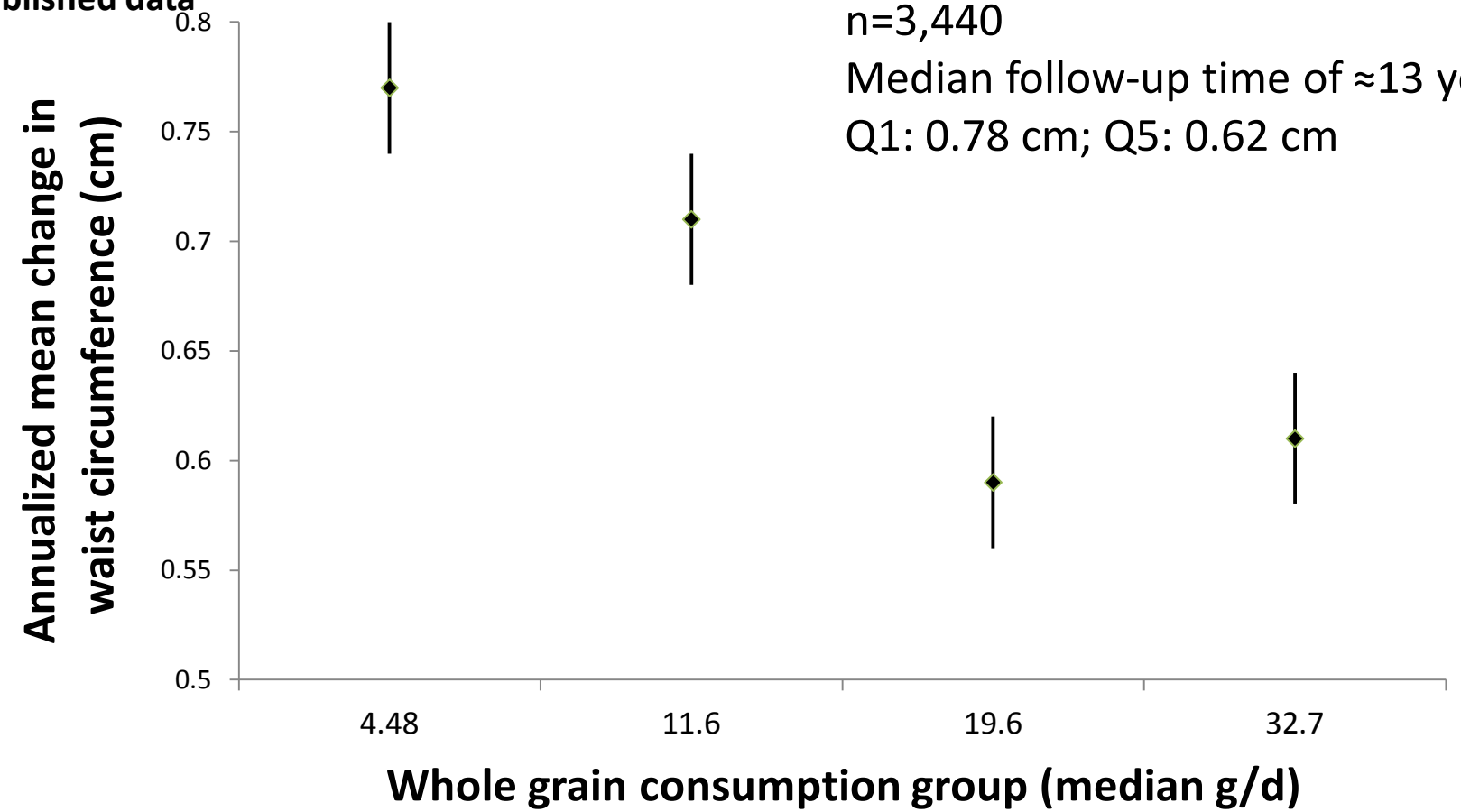
Després J et al. *Arterioscler Thromb Vasc Biol*. 2008;28:1039-1049.

Prospective Evidence: Higher Whole Grain Intake lower Gains in Weight and Waist Circumference

Reference	Country	Exposure of Interest	Higher WG Intake Associated with	
			Less Weight Gain	Less Gain in Abdominal Adiposity
Adults				
Liu et al. (2003)	USA	Whole Grain	✓	-
Koj-Banerjee et al. (2004)	USA	Whole Grain	✓	-
Bazzano et al. (2005)	USA	WG RTEBC	✓	-
Du et al. (2010)	Europe	Cereal Fiber	✓	✓
Mozaffarian (2011)	USA	Whole Grain	✓	-
McKeown (in preparation)	USA	Whole Grain	X	✓
Adolescents				
Cheng et al. (2009)	Germany	Whole Grain	X	-
Summary	USA: 5/7	WG: 5/7	5/7	2

Greater Intake of Whole Grains is Linked to Smaller Annual Gain in Waist Circumference: Data from the Framingham Heart Study

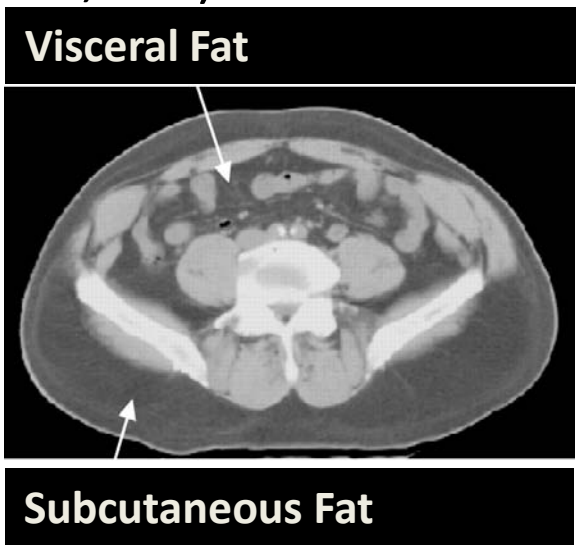
Unpublished data



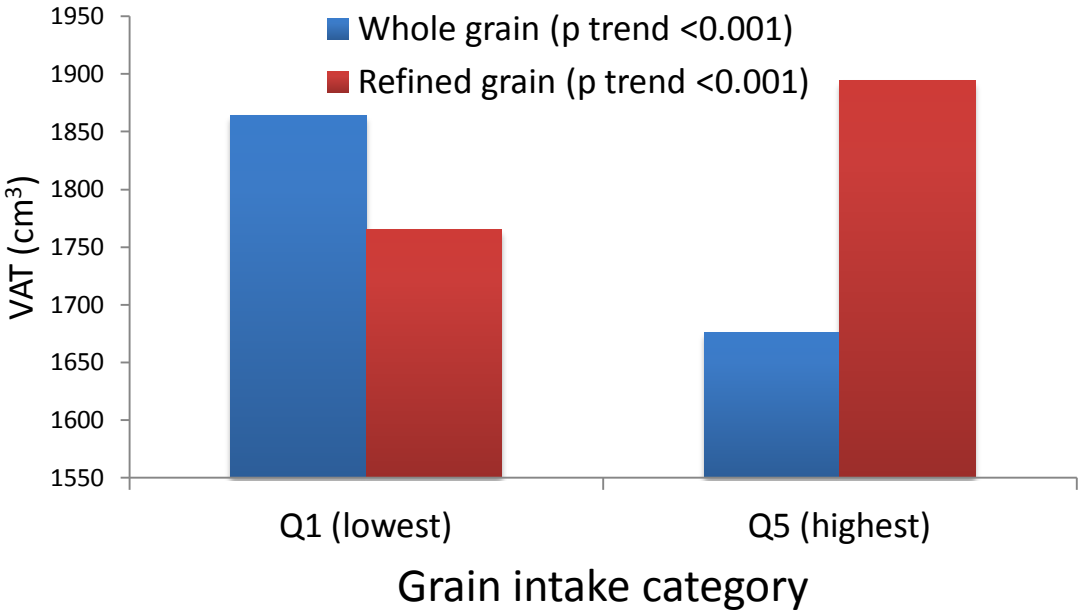
Adjusted for baseline waist circumference, medication, energy intake, sex, smoking, PA, DGAI

Whole- and Refined- Grain Intakes are Differentially Associated with Abdominal Visceral and Subcutaneous Adiposity

Framingham Heart Study (n=2,834)



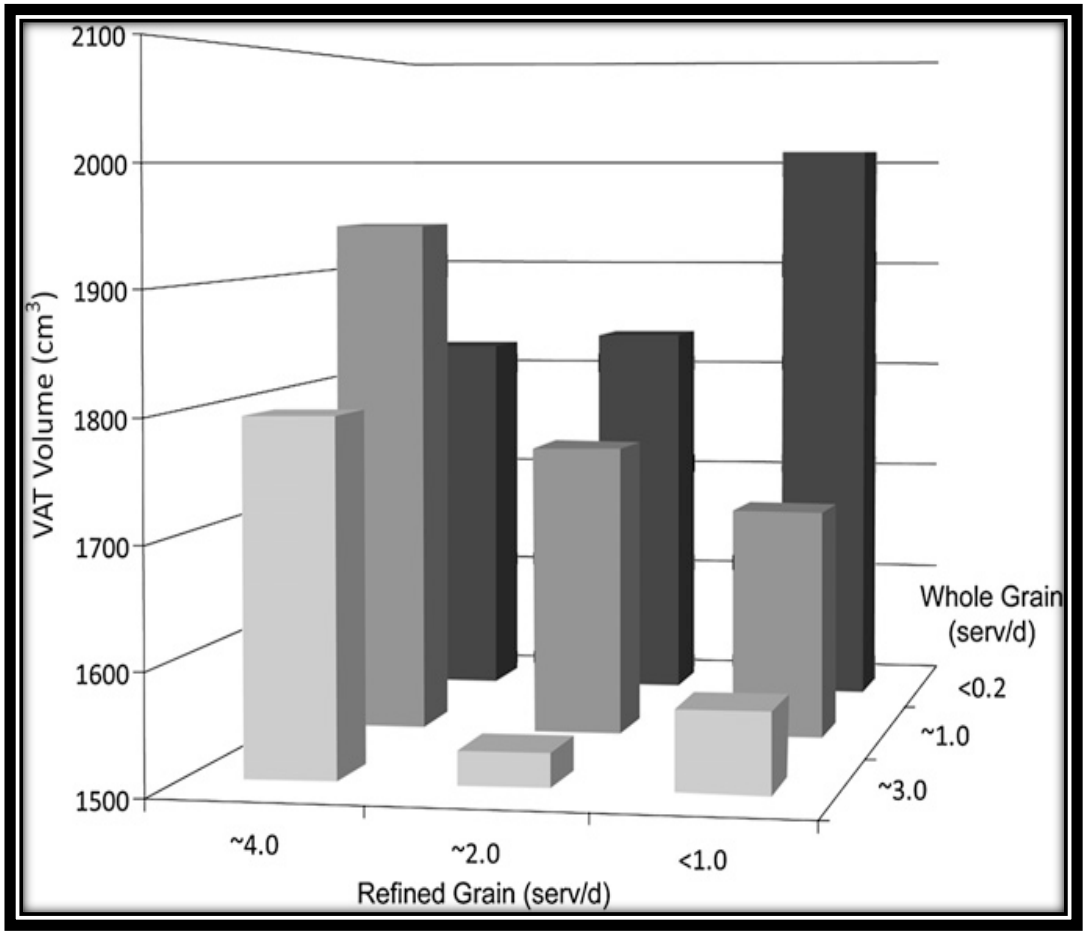
Mean multivariate-adjusted* VAT by whole and refined intake quintile categories



*adjusted for age, sex, smoking status, total energy, alcohol intake, SAT

McKeown et al. AJCN 2010 Nov;92(5):1165-71

Relationship Between Whole-Grains and Visceral Adipose Tissue in the Presence of Refined Grains



The association between high whole-grain intake and VAT was diminished in people consuming 4 servings refined grains/d, indicating *that refined grain may offset any potential benefits of whole grain on abdominal adiposity*

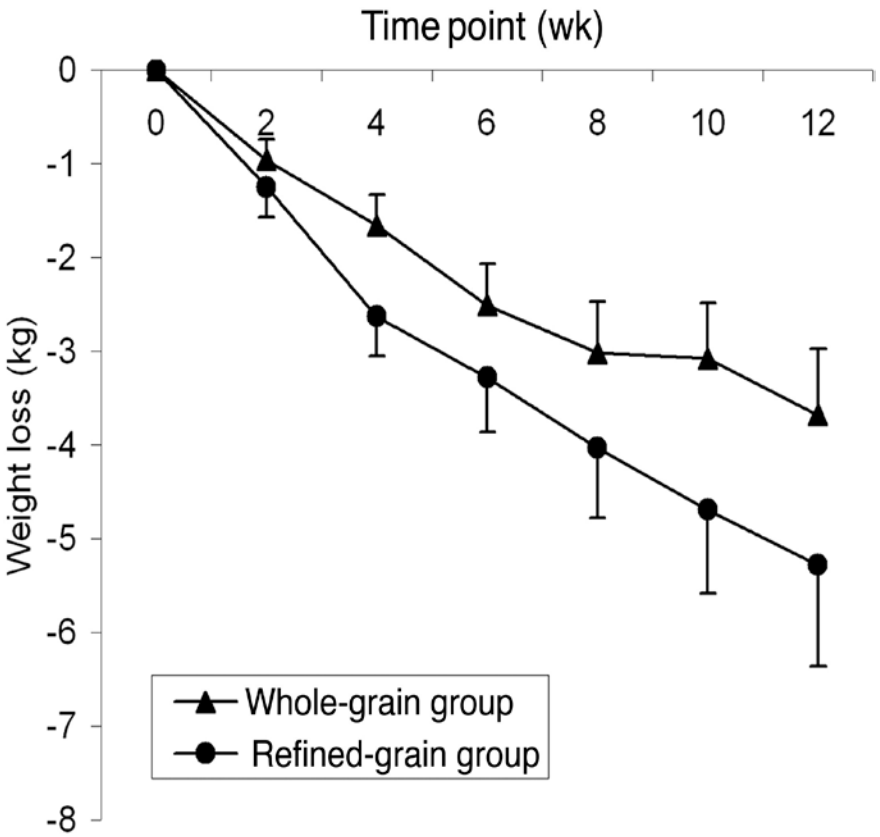
McKeown et al. AJCN 2010 Nov;92(5):1165-71

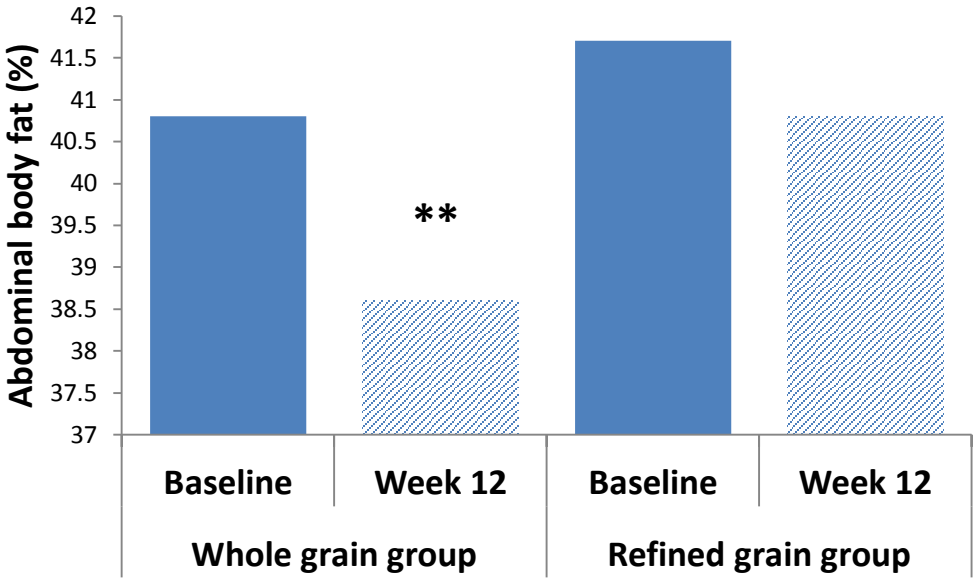
Effects of a Whole Grain Enriched Hypocaloric Diet on Measures of Body Composition in Adults with the Metabolic Syndrome

- Obese middle-aged adults (25 M, 25 F) with metabolic syndrome
- Randomized, open-label, parallel study for 12 weeks
- Energy restricted study
- Reach target for daily whole-grains (4,5,6 or 7 daily servings) or avoid whole grains
  - Whole grain diet = ≈5 serving/d whole grains
  - Refined grain diet = 0.2 servings/d whole grains

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

Effects of a Whole Grain Enriched Hypocaloric Diet on Measures of Body Composition in Adults with the Metabolic Syndrome





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

Whole grain and body weight changes in apparently healthy adults: a systematic review and meta-analysis of randomized controlled studies[1–3]

Am J Clin Nutr. 2013 Oct;98(4):872-84

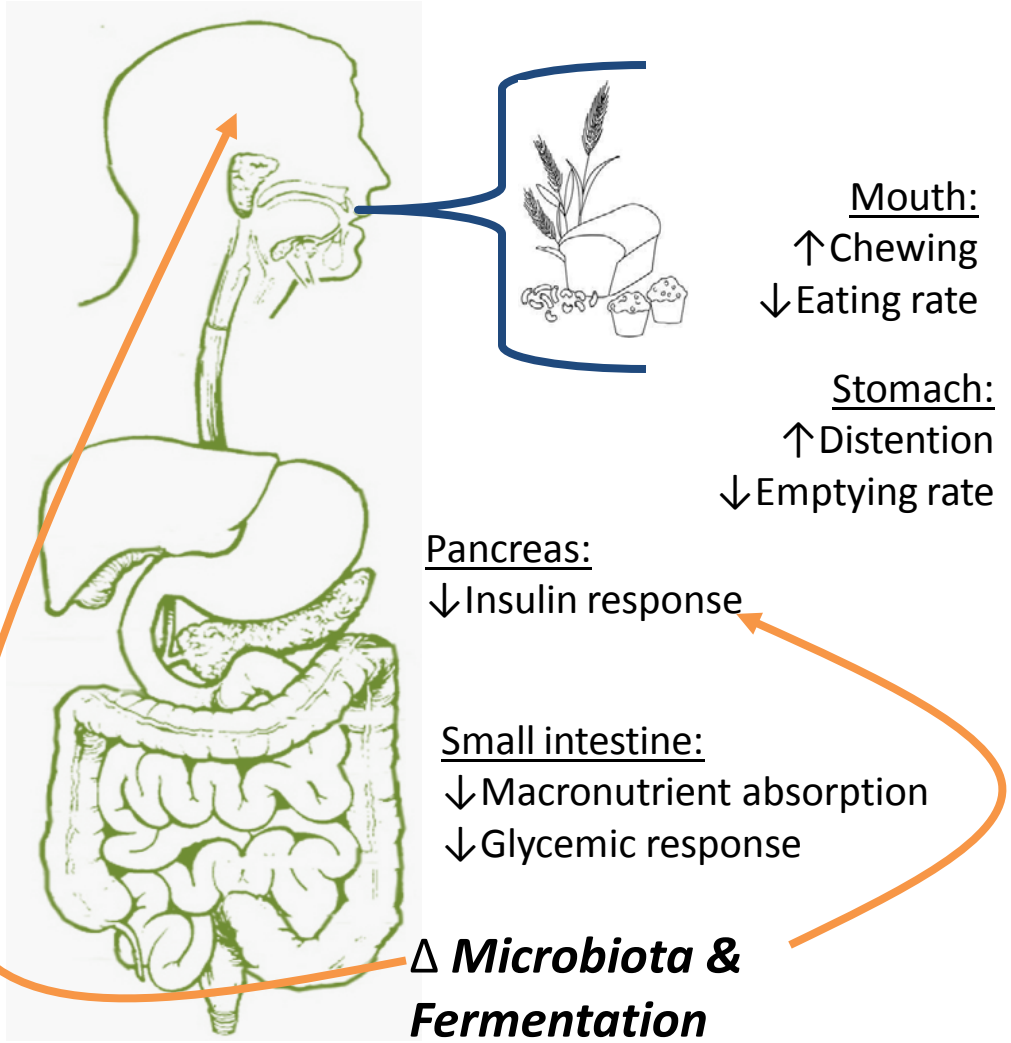
Korrie Pol, Robin Christensen, Else M Bartels, Anne Raben, Inge Tetens, and Mette Kristensen

- Data from 26 studies (n=2,060 participants)
  - Body weight
  - Body fat – **7 studies**
  - Waist circumference – 9 studies

Conclusion: Whole - grain consumption *does not decrease body weight compared to the control*, but a small beneficial effect on body fat may be present. The relatively short duration of intervention studies (<16 weeks) may explain the lack of difference in body weight and fat.

Potential Mediating Effects of Whole Grains On Body Weight

- Decreased dietary energy density
- Increased satiety
  - Slower gastric emptying
  - Slower digestion and absorption
- Reduce postprandial glycemic response
- ***Modulation of the gut microbiota***



Karl & Saltzman. Adv. Nutr. 3:697-707 (2012)

Prebiotic Effect

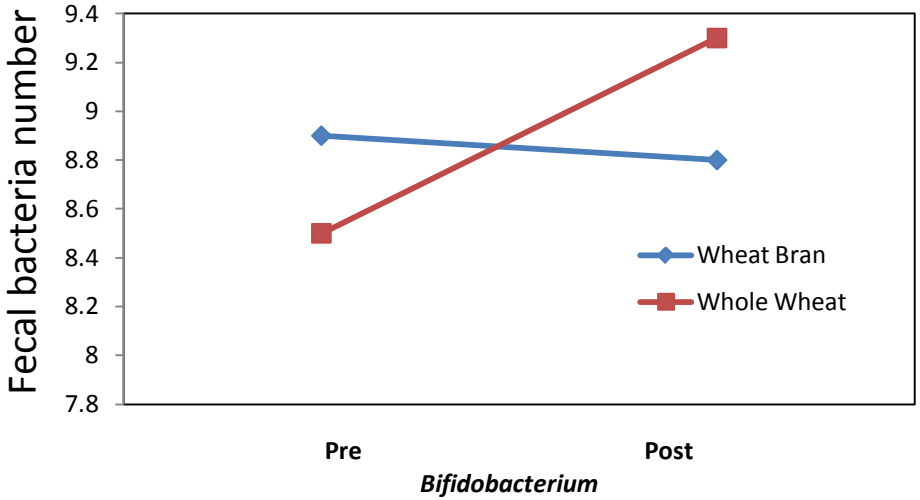
- Prebiotics are non-digestible carbohydrates resistant to stomach and small intestine secretions
- Reach the large intestine intact where they undergo selective fermentation and stimulate the growth and/or activity of healthy bacteria (i.e. bifidobacteria and lactobacilli)
- Formal definition

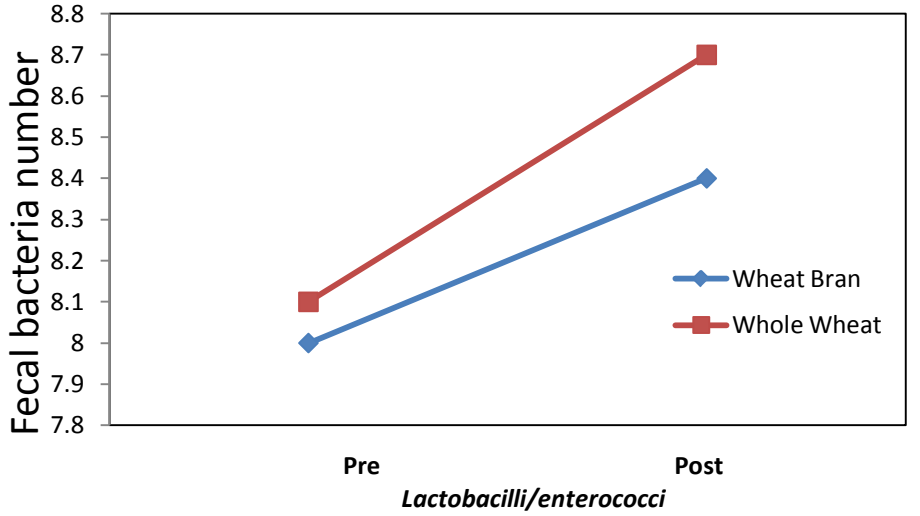
  "A selectively fermented ingredient that allows specific changes, both in the composition and/or activity of the gastrointestinal microbiota that confers benefits upon the host well-being and health" (Gibson, 2004)

Whole-grain wheat breakfast cereal has a prebiotic effect on the human gut microbiota: a double-blind, placebo-controlled, crossover study

Adele Costabile[1]*, Annett Klinder[1], Francesca Fava[1], Aurora Napolitano[2], Vincenzo Fogliano[2], Clare Leonard[3], Glenn R. Gibson[1] and Kieran M. Tuohy[1]

- A 3 week double blind cross-over study in 32 adults
- Diet
  - Whole grain wheat (48g/d)
  - Wheat bran (48g/d)
- A significant increase in bifidobacteria on whole grain wheat arm
- A significant increase in lactobaccilli on both arms



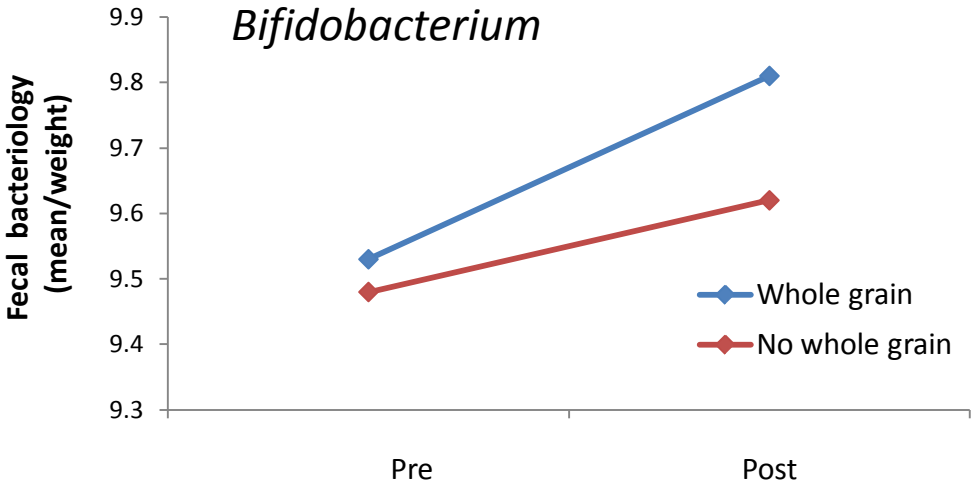


Br J Nutr. 2008;99:110–20.

Determination of the *in vivo* prebiotic potential of a maize-based whole grain breakfast cereal: a human feeding study

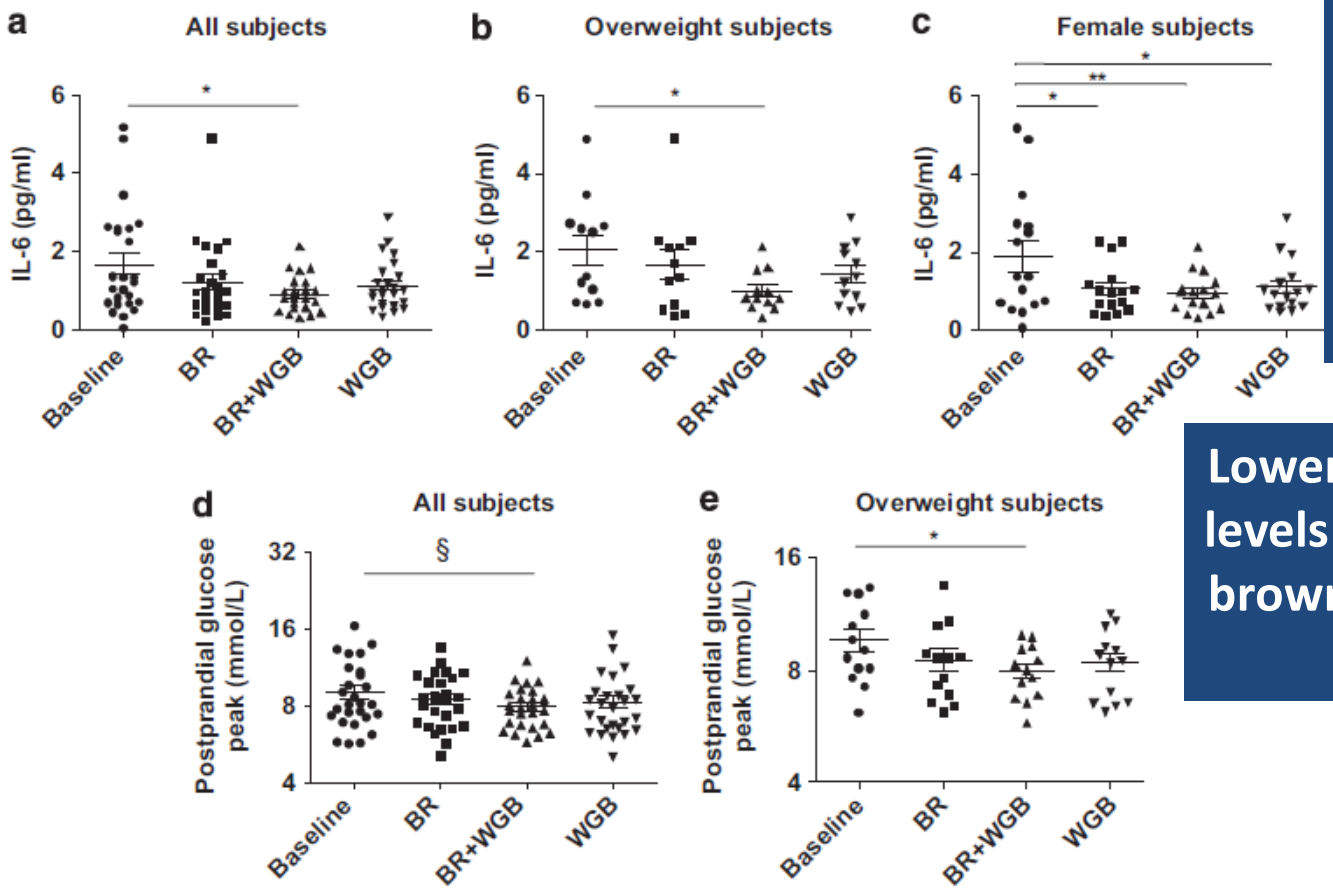
Andrew L. Carvalho-Wells[1]*, Kathrin Helmolz[2], Cecelia Nodet[2], Christine Molzer[2], Clare Leonard[3], Brigid McKevith[3], Frank Thielecke[3], Kim G. Jackson[1] and Kieran M. Tuohy[2]

- A 3 week double blind cross-over study in 32 healthy adults
- Diet
  - Non-whole grain (48g/d)
  - Whole grain cereal (48g/d)
- A significant increase in bifidobacterium after WG cereal consumption



Br J Nutr. 2010;104:1353-1356

Whole Grain Consumption (60g/4weeks) Induces Immunological & Metabolic Improvements



Plasma IL-6 levels decreased on the brown rice and whole grain barley diets Reduction was highest in overweight

Lower postprandial glucose levels during the combined brown rice and whole grain barley diets

Martinez et al, The ISME Journal (2013) 7, 269–280

These Whole-Grain Associated Improvements are Coincident with Altered Gut Microbiota

Table 2 Abundance of dominant bacterial taxa (% of total microbiota) in fecal samples as determined by 454 pyrosequencing (values are presented as mean ± s.d.)

	Baseline	*BR*	*BR+ WGB*	*WGB*	P-*value*	*Confirmation by linear model*
Genus						
Bacteroides	28.55 ± 15.73	22.89 ± 10.37	21.19 ± 11.87[a]	23.48 ± 12.62	0.022	Yes
Blautia	5.68 ± 3.15	7.61 ± 4.47	8.14 ± 3.97[b]	8.61 ± 4.32[b]	0.001	Yes
Ruminococcus	4.20 ± 4.91	5.35 ± 5.05	4.171 ± 5.75	3.46 ± 4.32	NS	Yes
Faecealibacterium	2.82 ± 2.38	3.06 ± 2.29	3.86 ± 3.22	3.86 ± 3.19	NS	Yes
Prevotella	2.79 ± 8.89	1.99 ± 6.24	3.34 ± 9.84	2.02 ± 6.30	NS	Yes
Dorea	2.59 ± 2.01	3.12 ± 2.22	3.08 ± 1.80	2.75 ± 1.86	NS	Yes
Parabacteroides	2.58 ± 3.05	2.06 ± 3.23	2.10 ± 3.14	1.59 ± 1.44	NS	Yes
Roseburia	1.98 ± 1.35	1.70 ± 1.25	2.42 ± 1.58	3.06 ± 2.91[e]	0.01	Yes
Akkermansia	1.85 ± 4.58	0.77 ± 1.53	0.68 ± 1.28	0.59 ± 0.80	NS	Yes
Coprococcus	1.82 ± 2.09	1.91 ± 2.08	1.47 ± 2.22	1.35 ± 1.78	NS	Yes
Alistipes	1.76 ± 2.08	1.67 ± 1.85	1.11 ± 1.05	1.34 ± 1.67	NS	Yes
Oscillibacter	1.27 ± 1.04	1.24 ± 1.00	1.08 ± 0.83	0.96 ± 0.61	NS	Yes
Bifidobacterium	0.99 ± 1.88	1.02 ± 1.64	1.95 ± 3.16	1.84 ± 2.54[d]	0.011	No
Subdoligranulum	0.94 ± 1.03	1.17 ± 1.43	1.42 ± 1.73	1.09 ± 1.02	NS	Yes
Dialister	0.75 ± 1.17	0.60 ± 0.89	0.94 ± 1.21	1.14 ± 1.69[d]	0.027	No
Odoribacter	0.26 ± 0.24	0.28 ± 0.35	0.28 ± 0.41	0.15 ± 0.18[b]	0.002	No

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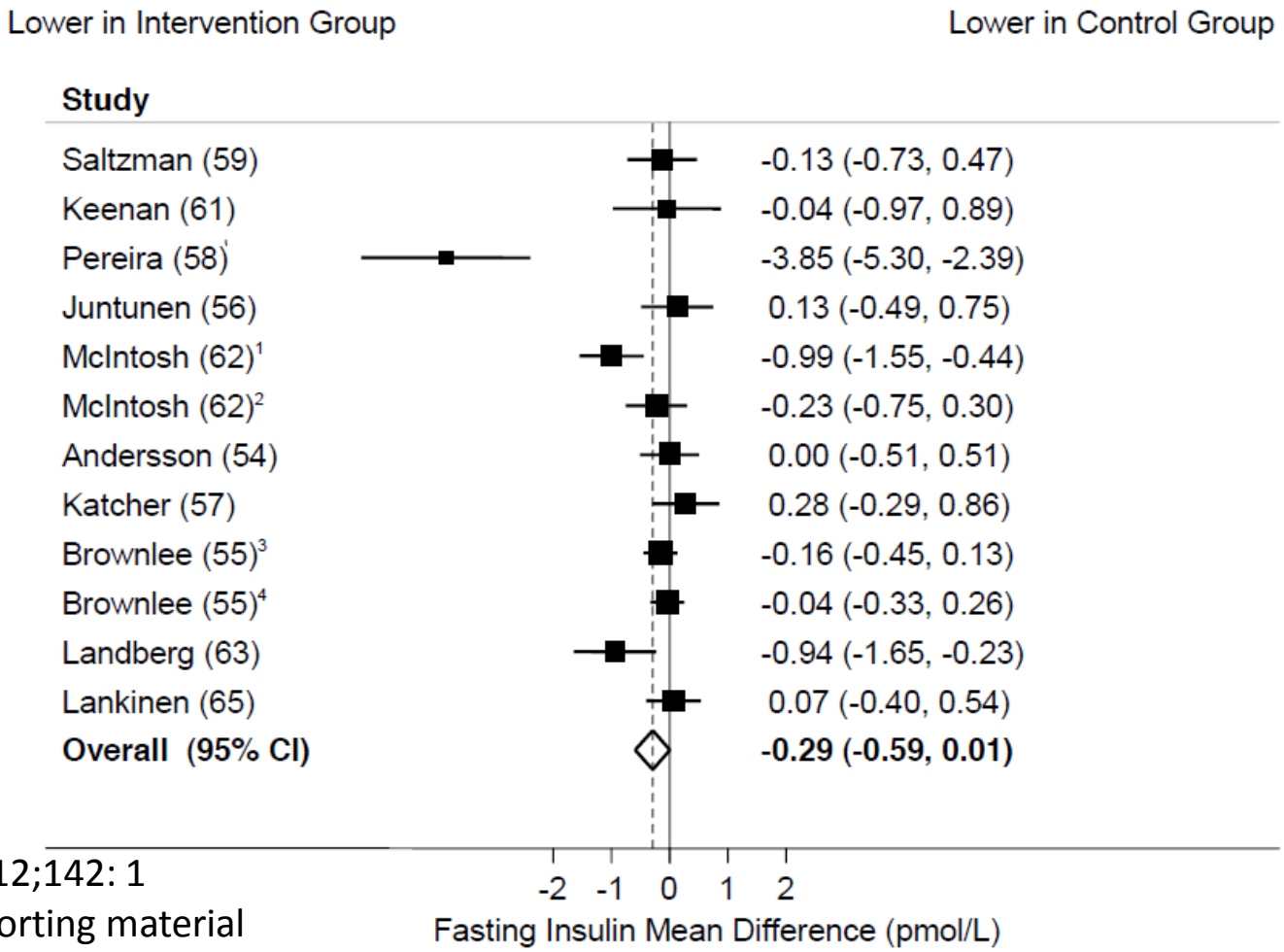
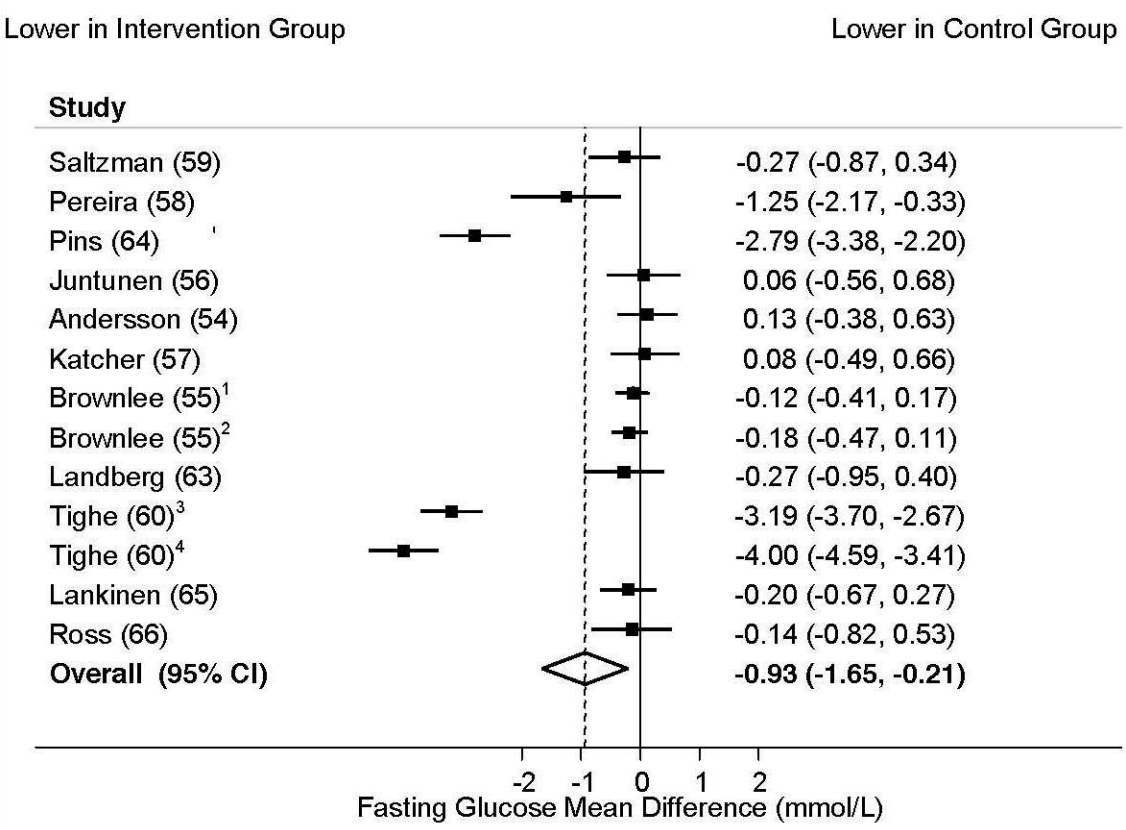
    - Gut microbiota
  - Surrogate risk factors for CVD
    - Glucose and Insulin Metabolism
    - Lipids
    - Blood Pressure
  - Cognition

No Improvement in Fasting Measures of Insulin Sensitivity with Higher Whole Grain Intake in Intervention Studies



Ye et al, J Nutr 2012;142: 1
304 – online supporting material

Concentrations of Fasting Glucose Lower with Higher Whole Grain Intake in Intervention Studies



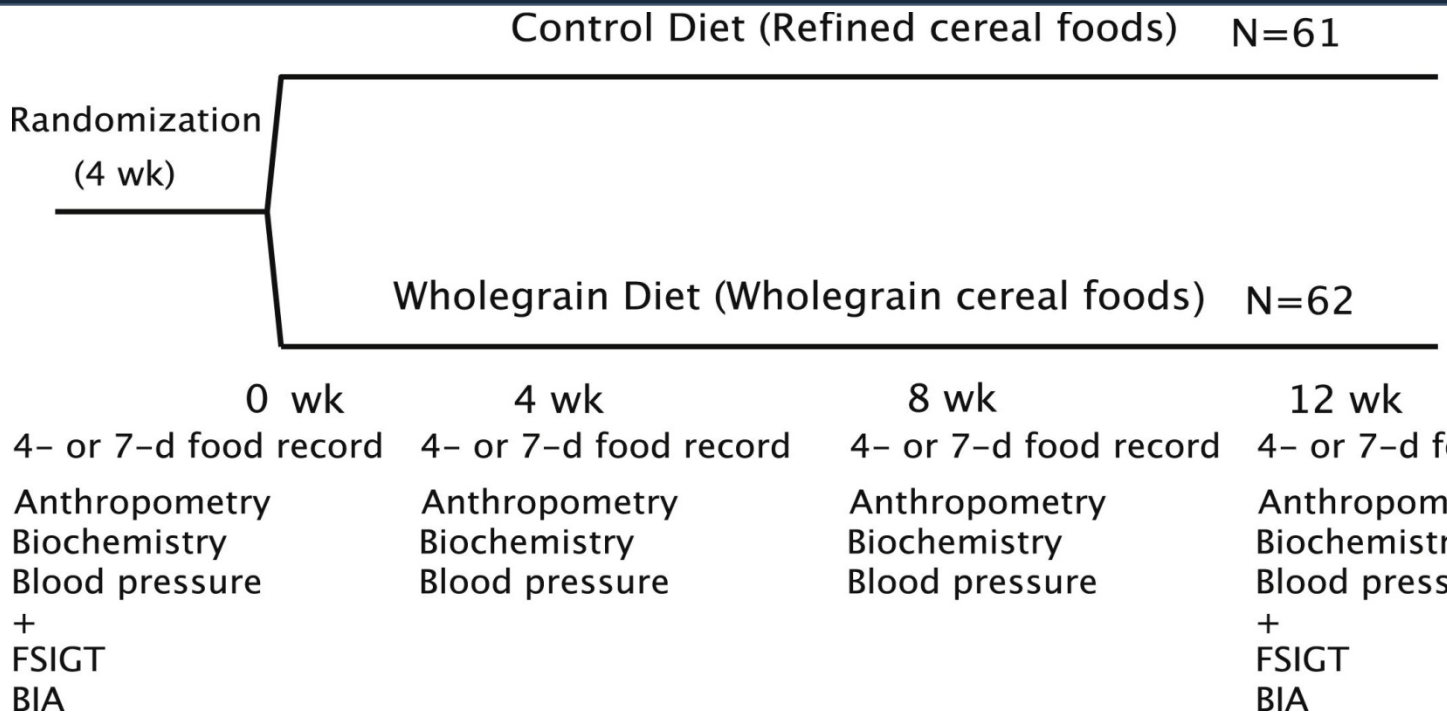
Weight mean difference in post-intervention concentration of fasting glucose

≈ 1 mmol/L (18 mg)

Ye et al, J Nutr 2012;142: 1304 – online supporting material

Effects of rye and whole wheat versus refined cereal foods on metabolic risk factors: A randomised controlled two-centre intervention study

Rosalba Giacco [a,*], Jenni Lappi [b], Giuseppina Costabile [c], Marjukka Kolehmainen [b], Ursula Schwab [b,d], Rikard Landberg [e], Matti Uusitupa [b], Kaisa Poutanen [b,f], Giovanni Pacini [g], Angela A. Rivellese [c], Gabriele Riccardi [a,c], Hannu Mykkänen [b]



Rye(Finland)
Whole-wheat (Italy)

Evaluate differences in glucose and insulin metabolism, as assessed by FSIGTT (frequently sampled intravenous glucose tolerance test) in response to whole-grain diets

Giacco et al. Clinical Nutrition, Volume 32, Issue 6, 2013, 941 - 949

Effects of rye and whole wheat versus refined cereal foods on metabolic risk factors: A randomised controlled two-centre intervention study

Rosalba Giacco [a,*], Jenni Lappi [b], Giuseppina Costabile [c], Marjukka Kolehmainen [b], Ursula Schwab [b,d], Rikard Landberg [e], Matti Uusitupa [b], Kaisa Poutanen [b,f], Giovanni Pacini [g], Angela A. Rivellese [c], Gabriele Riccardi [a,c], Hannu Mykkänen [b]

Conclusion: Wholegrain cereal foods consumption compared with refined cereals for 12 weeks did not affect peripheral insulin sensitivity.

Giacco et al. Clinical Nutrition, Volume 32, Issue 6, 2013, 941 – 949

Giacco et al. Clinical Nutrition, Volume 32, Issue 6, 2013, 941 - 949

ACCEPTED MANUSCRIPT

Whole-grain lowers postprandial plasma insulin and triglyceride concentrations in individuals with the metabolic syndrome

** In Naples Arm of study

R. Giacco[a], G. Costabile[b], G. Della Pepa[b], G. Anniballi[b], E. Griffo[b], A. Mangione[b], P. Cipriano[b], D. Viscovo[b], G. Clemente[a], R. Landberg[c], G. Pacini[d], A.A. Rivellese[b], G. Riccardi[b]

- Elevated postprandial glucose and insulin independent risk factors for CVD events
- Hypothesized that WG exert a metabolic effect mainly during postprandial period with minimum impact, at least in the short/medium term, on fasting parameters

Conclusion: A twelve week whole-grain cereal-based diet, compared to refined cereals, reduced postprandial insulin (by 29%) and triglyceride responses.

Nutrition, Metabolism and Cardiovascular Diseases

Mechanisms By Which Whole Grains May Attenuate Postprandial Blood Glucose

- Degree of processing/ particle size and structure
- Energy density
- Fiber composition
- Grain variety

Other…

- Food matrix
- Prior meal
- Meal volume

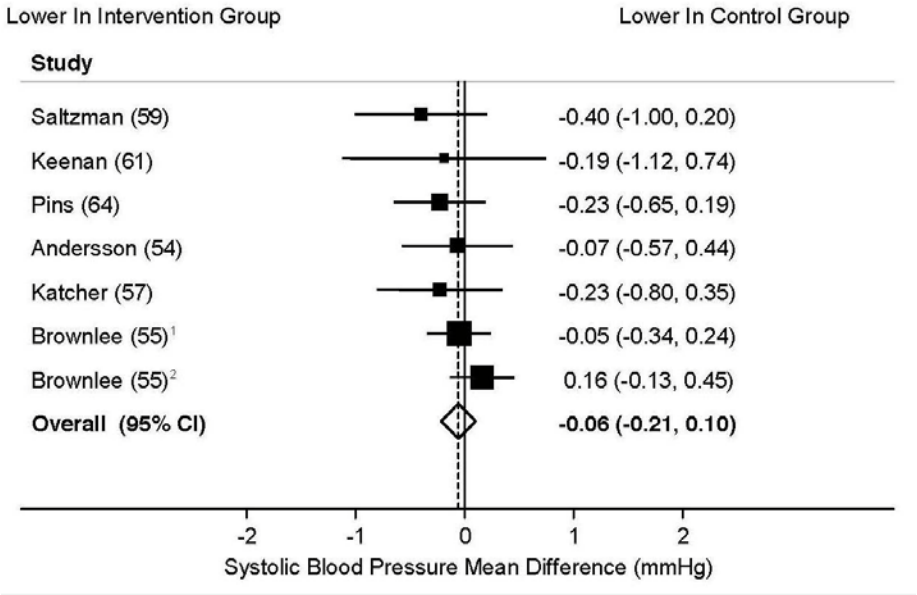
Whole Grains and Blood Lipids

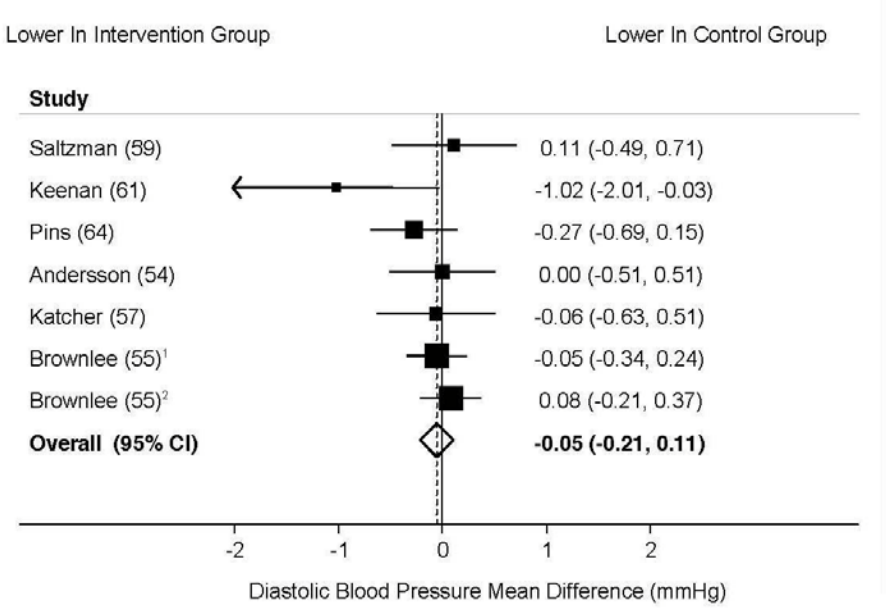
- "Consistent with prior studies, our meta-analysis indicated an increase intake of whole-grains for 4 to 16 weeks significantly improved an individuals lipid profile, reducing total cholesterol by 0.33 mmol/L and LDL cholesterol by 0.72 mmol/L" (Ye at al. 2012)

- "Intervention studies have demonstrated an overall effect of whole grains on total- and LDL- cholesterol, however, these cholesterol lowering effects were largely based on intervention studies in oats and barley" (Sinclair et al. 2013)

Whole Grains and Blood Pressure

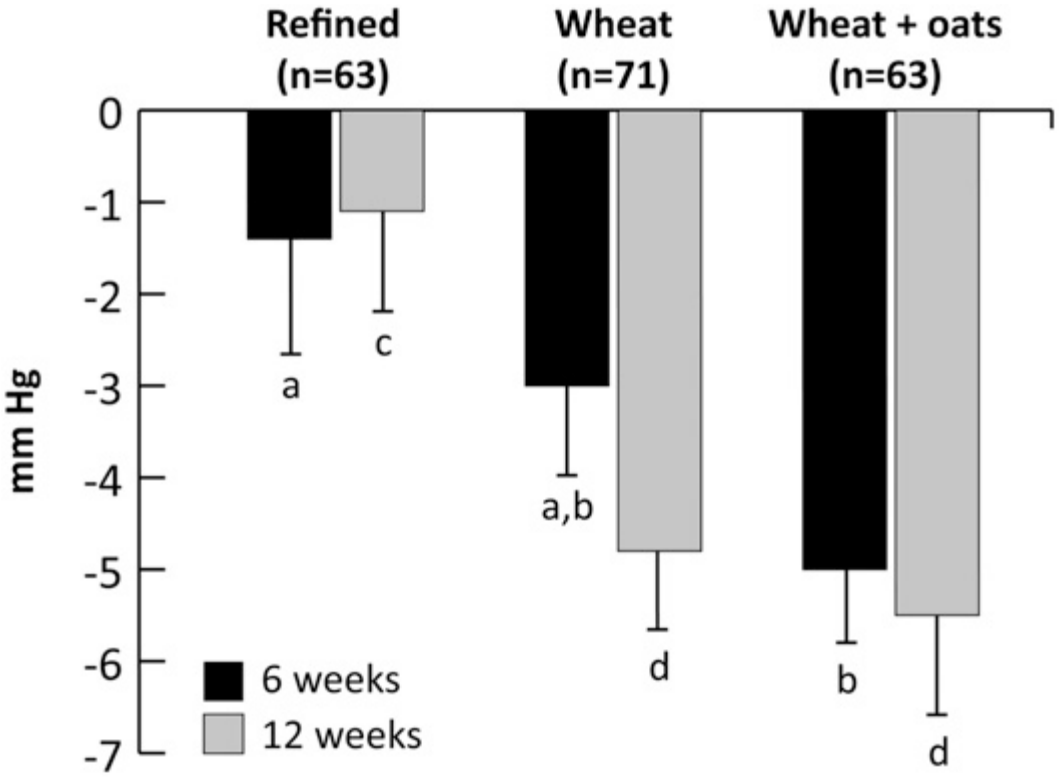
Weight mean differences after whole grain intervention vs. control in RCTs





Ye et al, J Nutr 2012;142: 1

Whole Grains and Blood Pressure

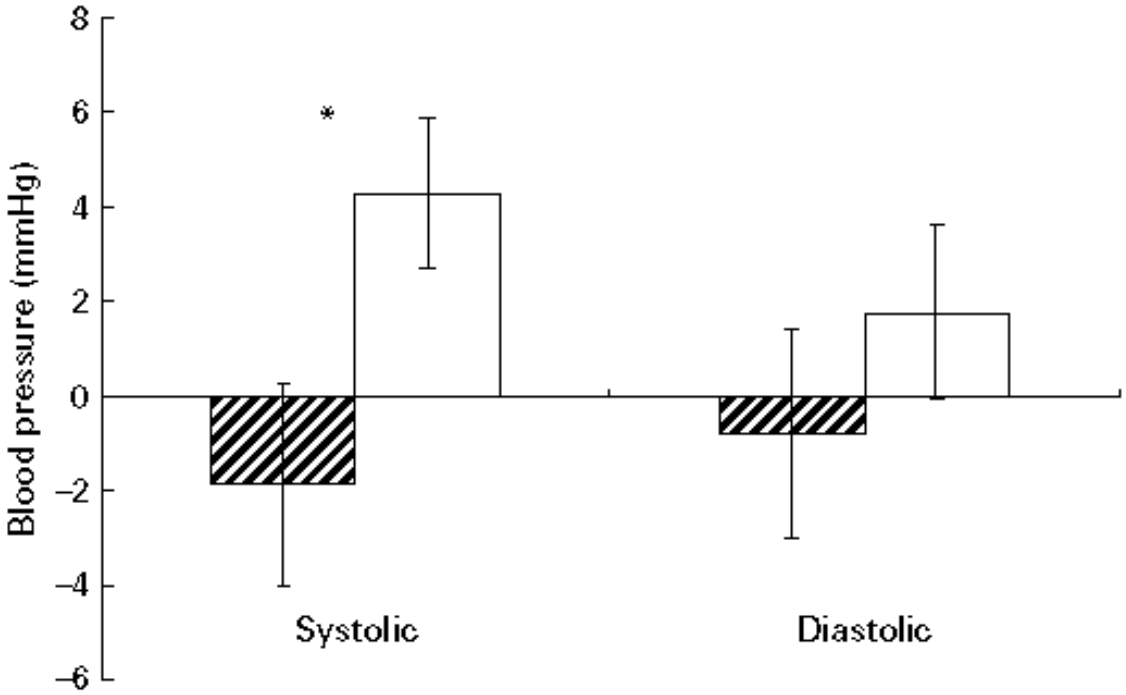


N=226

Reduced systolic blood pressure after consumption of 48g whole grain per day

Tighe *et al.* *Am J Clin Nutr* 2010; 92:733–740

Whole Grains and Blood Pressure



Reduced systolic blood pressure after consumption of 48g whole grain wheat per day for three weeks

Bodinham *et al.* *Br J Nutr* 2011; 106: 327-330

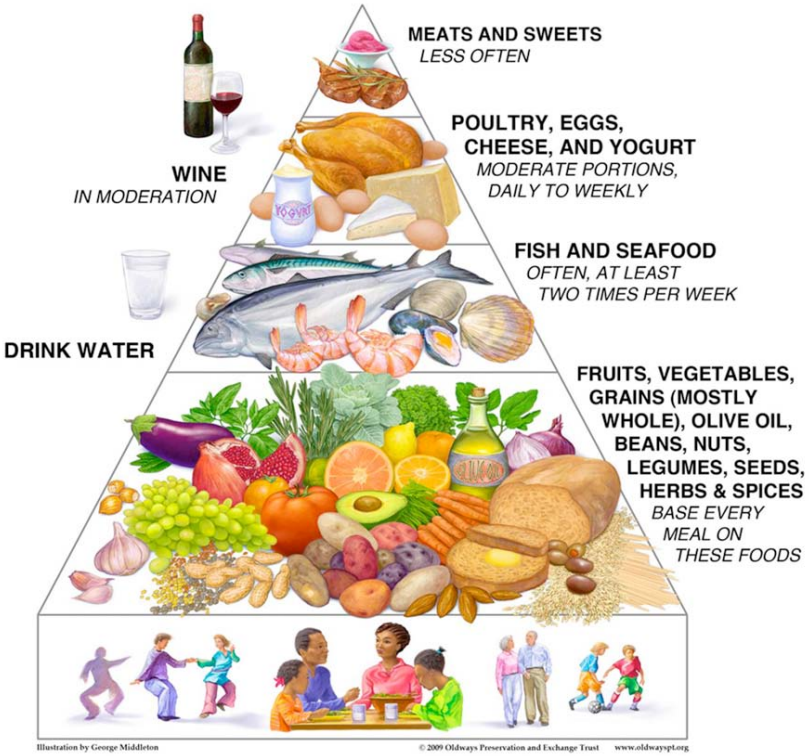
Presentation Roadmap

- Background
- Review of the Scientific Evidence
  - Obesity
    - -Gut microbiota
  - Surrogate risk factors for CVD
    - -Glucose and Insulin Metabolism
    - -Lipids
    - -Blood Pressure
  - Cognition

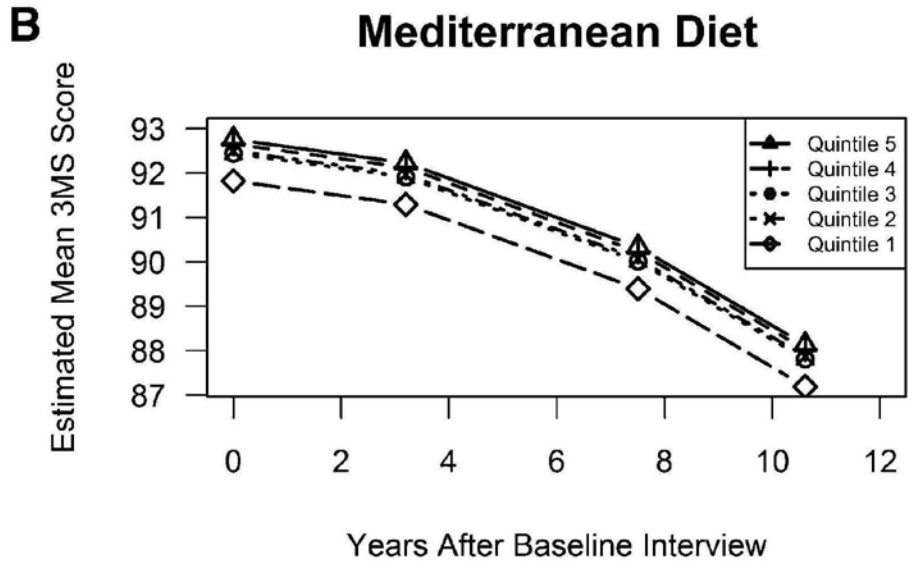
Prospective study of Dietary Approaches to Stop Hypertension– and Mediterranean-style dietary patterns and age-related cognitive change: the Cache County Study on Memory, Health and Aging[1–3]

Heidi Wengreen, Ronald G Munger, Adele Cutler, Anna Quach, Austin Bowles, Christopher Corcoran, JoAnn T Tschanz, Maria C Norton, and Kathleen A Welsh-Bohmer

AJCN 2013;98:1263-71



- High intake of fruit, vegetables, & **grains**
- Olive (canola) oil as primary source of oil/fat
- Fish intake at least weekly
- Moderate intake of meat
- Daily physical activity



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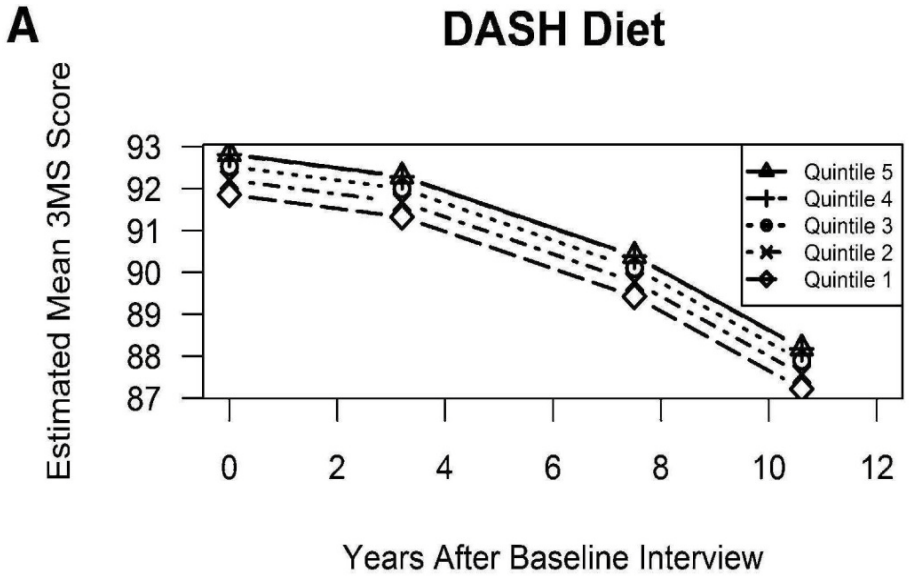
DASH DIET Type of Food	Servings on a 2000 calorie diet
Grains & grain products (include at least 3 WG foods each day)	7-8
Fruits	4-5
Vegetables	4-5
Low fat or non fat dairy foods	2-3
Lean meats, fish, poultry	2 or less
Nuts, seeds, & legumes	4-5/week
Fats & sweets	Limited



Prospective study of Dietary Approaches to Stop Hypertension– and Mediterranean-style dietary patterns and age-related cognitive change: the Cache County Study on Memory, Health and Aging[1–3]

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Conclusion: Higher levels of accordance with both the DASH and Mediterranean dietary patterns were associated with consistently higher levels of cognitive function in elderly men and women over 11 y period. **Whole grains and nuts and legumes were positively associated with higher cognitive functions and may be core neuroprotective foods common to various healthy plant-centered diets around the globe.**

Presentation Roadmap

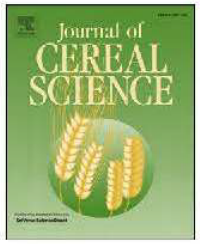
- Background
- Review of the Scientific Evidence
- Conclusions
  - Summary of the science
  - Practical advice

Whole Grains & Obesity Conclusion

Contents lists available at SciVerse ScienceDirect

Journal of Cereal Science

journal homepage: www.elsevier.com/locate/jcs



Review

Does wheat make us fat and sick?☆

Fred J.P.H. Brouns [a,*], Vincent J. van Buul [a], Peter R. Shewry [b]

[a] *Maastricht University, Faculty of Health, Medicine and Life Sciences, Department of Human Biology, Health Food Innovation Management, P.O. Box 616, 6200 MD Maastricht, The Netherlands*

[b] *Rothamsted Research, Plant Biology and Crop Science, West Common, Harpenden, Hertfordshire AL5 2JQ, United Kingdom*

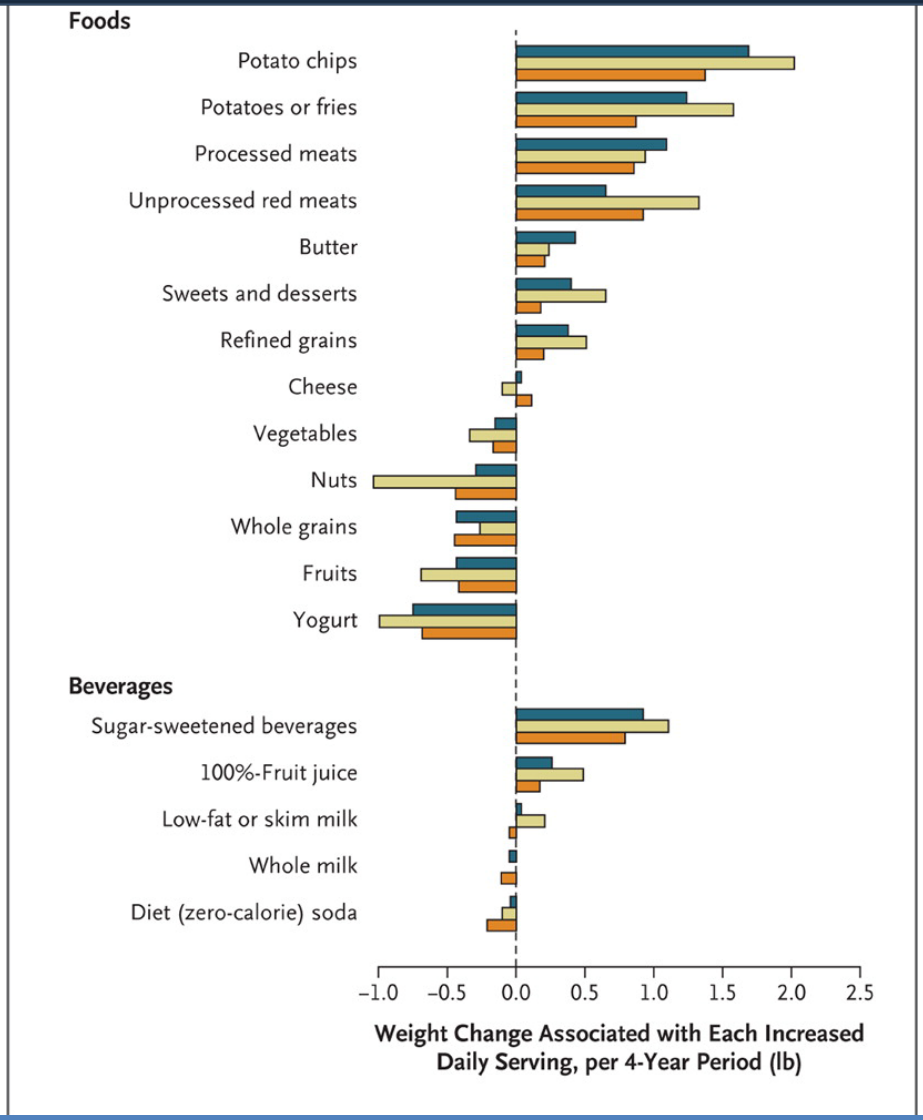
"Based on the available evidence, we conclude that whole-wheat consumption cannot be linked to increased prevalence of obesity in the general population"

OBESITY HAS A MULTIFACTORIAL CAUSATION !!!!

Changes in Food & Beverage Consumption and Weight Changes Every 4 Years

- NHS: n=50,422; 20 year follow-up
- NHS II: n=47,898; 12 year follow-up
- HPFS: n=22,557; 20 year follow-up

"We found that multiple lifestyle changes were independently associated with long-term weight gain, including changes in the consumption of specific foods and beverages, physical activity, alcohol use, television watching, and smoking habit"



Mozaffarian D et al. N Engl J Med 2011;364:2392-2404.

Summary of the Scientific Evidence

- Prospective cohort studies
  - Show consistent findings for most health outcomes
  - Supported by trials of surrogate outcomes for total and LDL cholesterol and fasting glucose.
- Inconsistency between cohort and trial finding
  - Lack of consistency between trials (interventions)
  - Variation in study design, study population, whole grain sources, study duration
  - Different paradigm/different hypotheses
- Emerging mechanisms on whole-grains and health
  - Gut microbiota
  - Post-prandial excursions

Increasing Whole Grain Consumption

- Encourage incorporating whole grains as part of a healthy diet
- Eat a variety of whole grains
- Good sources of fiber (3 g fiber); excellent sources (>5g)
- Whole grains contribute to the dietary deficit (but so do fruits/veg/legumes)
- Substitute refined grains for whole grains
- Check out: supertracker.usda.gov

"Ease up on the dinosaur meat and eat more whole grains."

Many Refined Grains Come Packaged in Sugar, Salt, and Fat (and lack fiber)

- Replacing whole grains with refined or processed counterparts usually changes the nutrient profile of the food
- Compare the nutrient profiles for **1 serving** of each the following:

Oatmeal, 1 cup (whole oats cooked in water)

- Sugar – 0.63g
- Sodium – 9mg
- Fat – 3.56g
- Fiber –4.0g

Popular Breakfast Cereal Made of Rice that Crackles, 1 cup

- Sugar – 2.86g
- Sodium - 153mg
- Fat – 0.59g
- Fiber – 0.1g

Whole Grain Bread, 1 large slice

- Sugar – 2.62g
- Sodium –156mg
- Fat – 1.73g
- Fiber – 3.0g

Croissant, 1 medium

- Sugar – 6.42g
- Sodium – 266mg
- Fat – 11.97g
- Fiber – 1.5g

USDA Nutrient Database: Accessed online 2/14 at http://ndb.nal.usda.gov/ndb/search/list

Whole Wheat Family

- Wheat or whole grains related to wheat
- WW relations contain less gluten than regular wheat, but are not gluten free
- Delicious flavor and packed with vitamins, minerals, and fiber compared to processed grains!

Wheatberries		Use as the base for cold salads
Spelt		Add to soups
Kamut / Khorasan wheat		Make warm savory dishes
Farro		Add to salads or soups
Whole wheat and spelt flours		Use in baking like white flour, just add a little extra leavening

Ancient Grains

- Commonly considered grains even though some do not come from grasses
- Do not contain gluten so are safe for people with celiac disease
- Making a comeback in modern cooking!

Amaranth		Staple grain of the Aztecs, eat toasted or puffed as cereal
Quinoa		Cultivated in pre-Columbian Andes region. Eat as a grain dish like rice
Buckwheat		Used as a breakfast grain, in soba noodles, or in cold salad
Millet		Millet porridge, millet flour, or in savory stews
Teff		Ethiopian injera bread, often used as a gluten-free four

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- Micaela Karlsen, PhD student
- Jiantao Ma, PhD student
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Questions?