

Whole Grains and Health: A Roundup of the Latest Research



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Outline



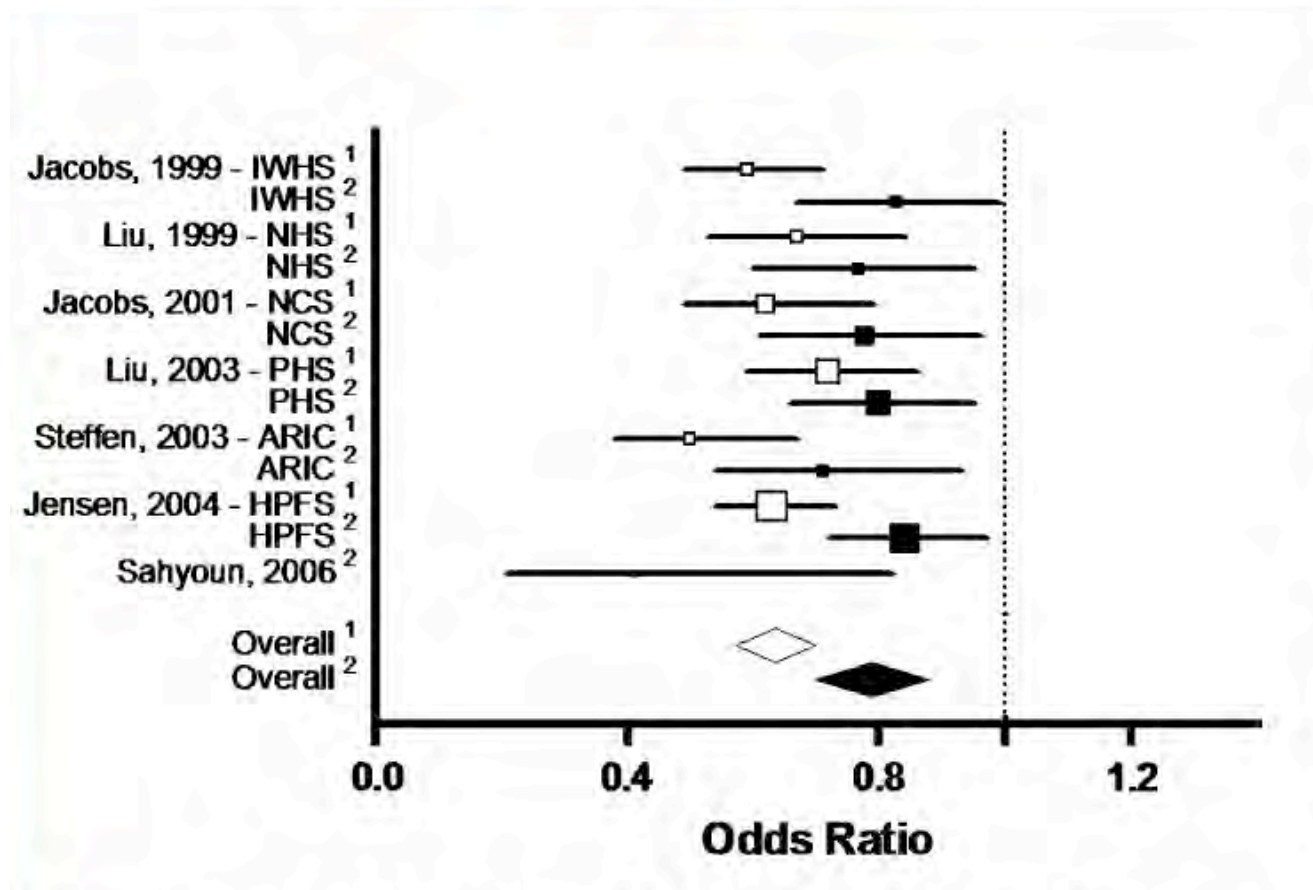
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- Whole grain benefits
 - CVD
 - Weight Management
 - Diabetes & Metabolic Syndrome
 - Cancer
 - Benefits go beyond fiber
 - Bran, endosperm, germ
 - Antioxidants, polyphenols, phytosterols
-

Whole Grain Foods



- Whole wheat and whole wheat flour
 - Whole oats and whole oat flour
 - Whole cornmeal and whole corn flour
 - Brown rice and brown rice flour
 - Whole rye and whole rye flour
 - Whole barley
 - Bulgur
 - Buckwheat
 - Popcorn
 - Amaranth
 - Psyllium
-
-

Inverse Association Between Whole Grain Intake and Cardiovascular Disease



¹Demographic adjusted model

²Demographic plus risk factor adjusted model

Mellon et al., Nutr Metab & Cardiovasc Dis. 18: 283-290, 2008

Summary of Large-Scale Observational Studies Showing a Benefit of Increased Whole Grain Consumption on CVD Risk*

Study Data Source	Reported Association/Outcome	Reference
Health Professionals Follow-Up (42,850 adult men), 14 years of follow-up	18% reduction in coronary heart disease	(Jensen et al 2004)
Nurse's Health Study (75,521 adult women), up to 12 years follow-up	36% reduction in ischemic stroke	(Liu et al 2000)
Iowa Women's Health Study (38,470 postmenopausal women), 9 years of follow-up	18% reduction in all cardiovascular disease deaths 18% reduction in coronary heart disease	(Jacobs et al 1999)
Iowa Women's Health Study (34,491 postmenopausal women), 9 years of follow-up	30% reduction in ischemic heart disease death	(Jacobs et al 1998)
U.S., Boston adult 535 men and women	52% reduction in CVD mortality	(Sahyoun et al 2006)
Atherosclerosis Risk in Communities (ARIC) Study (15,972 adult men and women), 11 year follow-up	23% reduction in all-cause mortality 28% reduction in incident coronary artery	(Steffen et al 2003)

*Only significant differences are reported unless otherwise stated ($P < 0.05$).

Whole Grains & Stroke: Epidemiological Evidence

- Harvard Nurses' Health Study (75,000 women)

3 servings of
whole grain
food/day



36% ↓ risk of
ischemic stroke
(24% after
controlling for fiber)

Whole Grain Intake and Incident of Hypertension In Men: Health Professionals Follow-Up Study, 1986-2004

	Quintile of whole grain intake					<i>P</i> for trend
	1	2	3	4	5	
Median intake (g/d)	3.3	9.8	17.1	26.9	46.0	—
No. of cases	1826	1917	1922	1914	1648	—
Person-years	61,137	68,966	72,196	73,184	69,877	—
Age- and energy-adjusted RR	1.00	0.90	0.83	0.81	0.72	<0.0001
Multivariate-adjusted RR	1.00	0.94	0.89	0.89	0.81	<0.0001

Whole Grains & Heart Disease: Effect on Blood Lipids

Whole grains lower cholesterol levels in part because of a high level of viscous (soluble) fiber

- Oats added to diet DeGroot et al., 1963
 - **↓ cholesterol 5-8%**
- Whole grain cereal & AHA Step One diet Johnston et al., 1998
 - **↓ cholesterol 4%**
- FDA Health Claim - 3 grams of viscous (soluble) fiber from whole grain oats or oat bran
 - **↓ cholesterol 5-6mg/dL** Ripsin et al., 1992
- Whole wheat vs refined wheat Giacco et al., 2009
 - **↓ cholesterol 4%**



Whole Grains & CVD Risk Reduction: Potential Mechanisms

- Soluble Fiber
- LDL Oxidation
- Vascular Reactivity
- Coagulation and Fibrinolysis
- Insulin Sensitivity
- Homocysteine

Whole Grains & Obesity: Epidemiological Studies



NHANES 1999-2000

Whole Grain (WG) Intake (sv/d) Inversely Associated
with BMI and Waist Circumference in Adult Women

	WG = 0 sv/d	0 < WG <1 sv/d	WG \geq 1 sv/d
BMI	29.0 \pm 0.3	28.2 \pm 0.4	27.1 \pm 0.5 ^a
Waist Circumference	93.9 \pm 0.9	91.8 \pm 1.1	90.3 \pm 1.3 ^a

^a Means with superscripts are significantly different from 0 WG servings/day, $p < 0.05$

Whole Grains & Obesity: Epidemiological Studies

Higher Whole Grain (WG) Intake (3 servings/day) is associated with Lower BMI

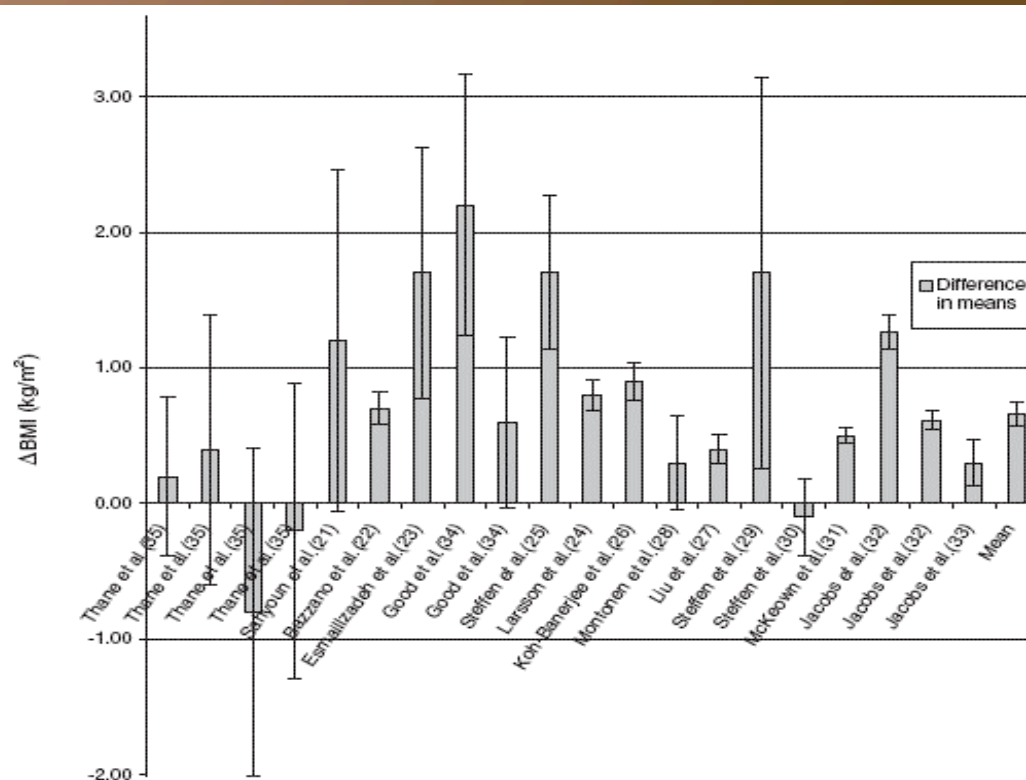
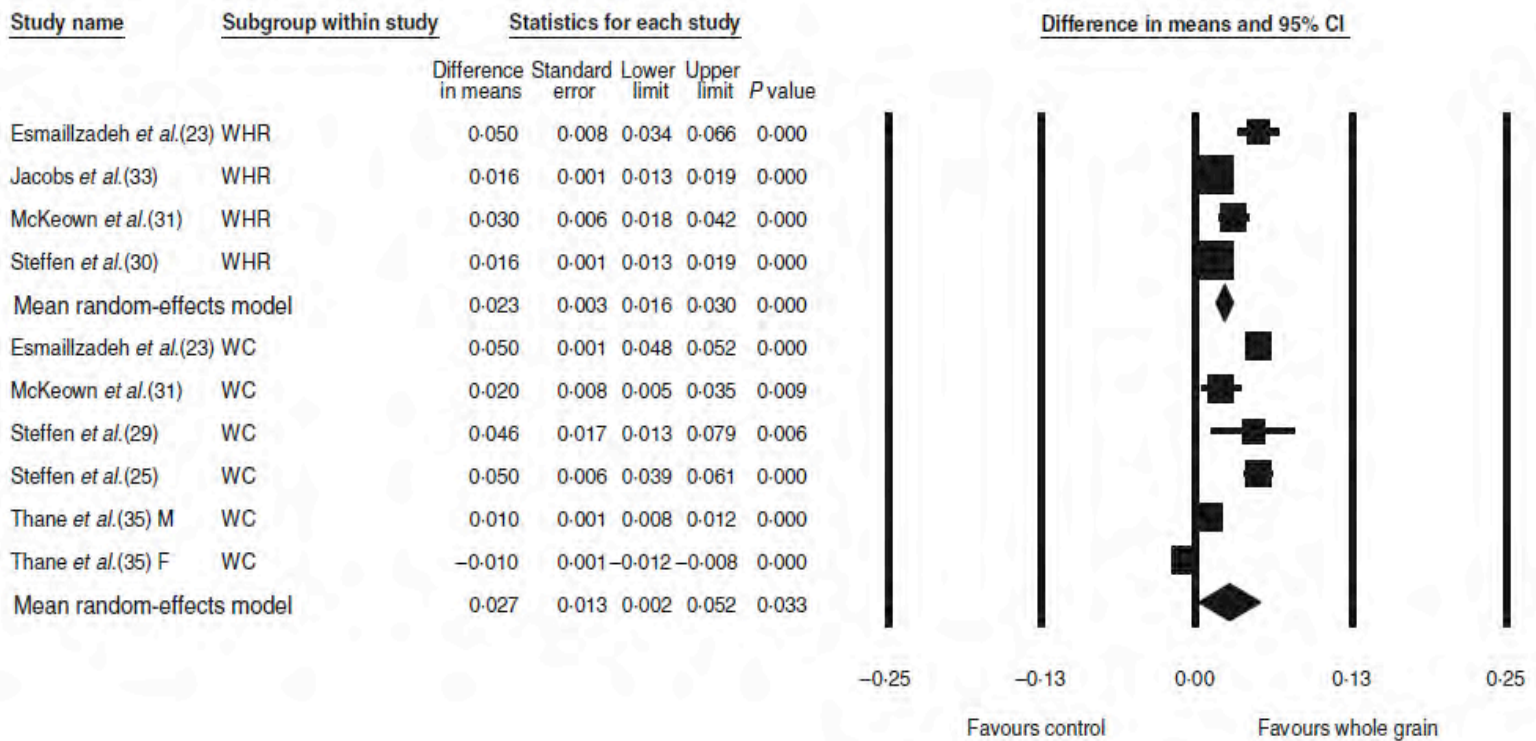


Fig. 2 Mean difference in body mass index (Δ BMI) in non- or low consumers of whole grains compared with high consumers of whole grains (95 % confidence interval shown by vertical bars)

Whole Grains and Waist Circumference: Epidemiological Studies

Higher Whole Grain (WG) Intake (3 servings/day) is associated with Lower Central Adiposity



Mean difference (and 95% confidence interval, CI) in waist:hip ratio (WHR) or waist circumference (WC) when low or no whole-grain intake is compared with high intake

Means and percentages of body mass index and insulin, by category of whole grain intake, MESA 2000–2002

	Whole Grain Intake Category					<i>P</i> trend
	1	2	3	4	5	
Median whole grain intake	0.02	0.15	0.39	0.72	1.39	
N	1069	1137	1072	1121	1097	
BMI	28.2	28.2	27.9	27.8	27.6	<0.0001
Insulin	5.37	5.42	5.42	5.19	5.16	<0.002



Whole Grains & Obesity: Potential Mechanisms

- High volume, high fiber, low energy density
- Prolonged gastric emptying
- Increased insulin sensitivity
- Secretion of gut hormones

Whole-grain intake is inversely associated with the metabolic syndrome and mortality in older adults

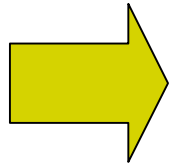
The study population was composed of 179 (33%) men and 356 (67%) women with an average age of 72.1 y for men and 73.4 y for women

Variables	Grain intake				P for trend ¹
	Q1	Q2	Q3	Q4	
Whole grain					
<i>n</i>	135	132	135	133	
Median whole grain intake (servings/d) ²	0.31	0.86	1.49	2.90	0.001
BMI (kg/m ²)	26.4	25.5	25.3	25.2	0.03
Glucose (mg/dL)	114.9	113.1	111.5	108.5	0.01
Metabolic syndrome (Odds ratios)	1.00	0.58	0.41	0.46	0.005

Whole Grains & Type 2 Diabetes: Epidemiological Studies

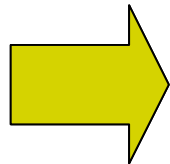


Intake of
about 3
servings of
whole
grains/day



Data from the IOWA Women's Health
Study

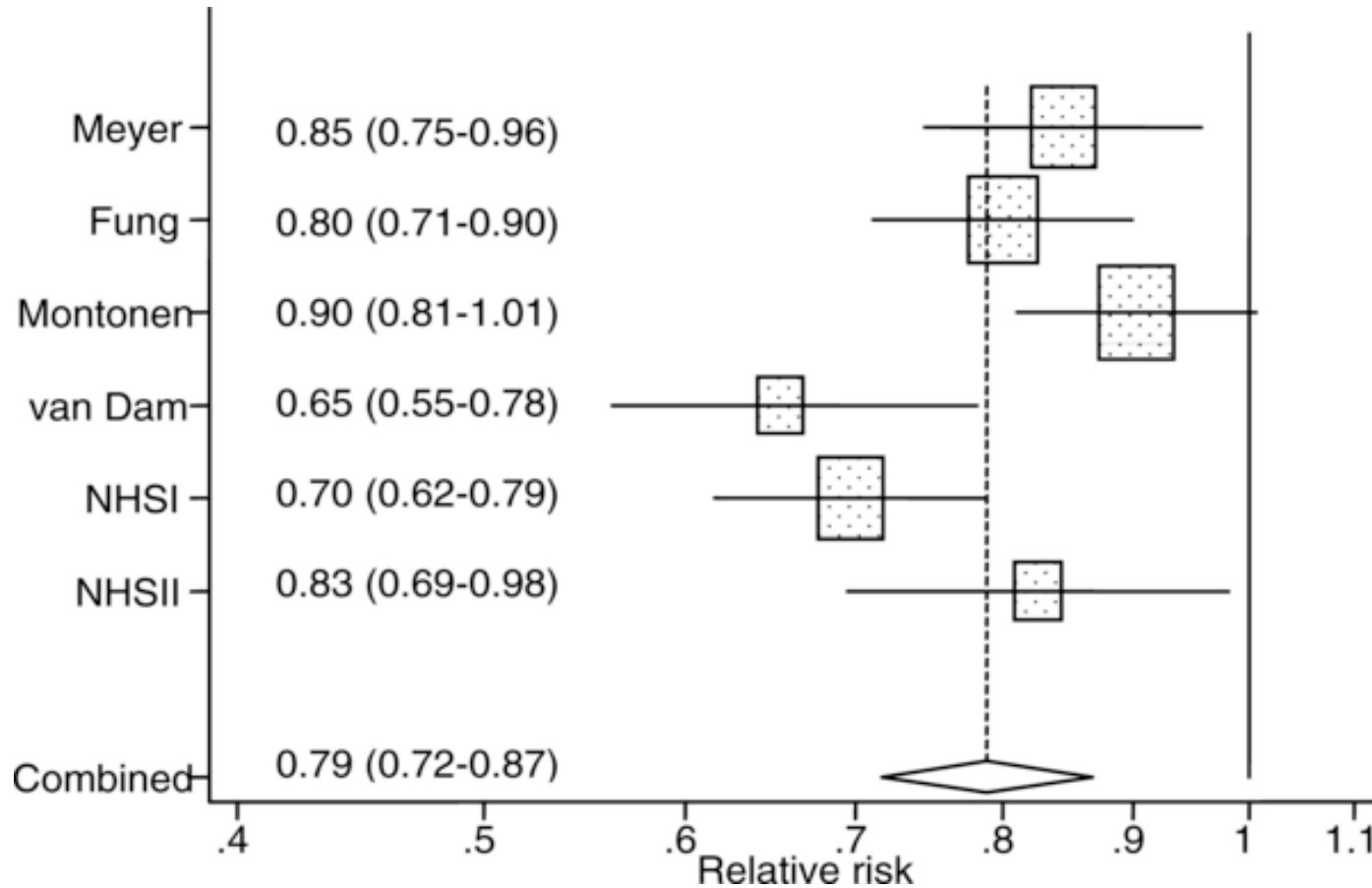
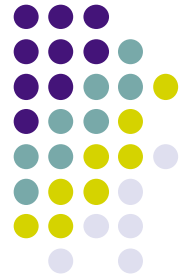
21 % ↓ risk of Type 2 diabetes



Data from the Nurses' Health Study

27 % ↓ risk of Type 2 diabetes

Inverse Association Between Whole Grain Intake and Type 2 Diabetes





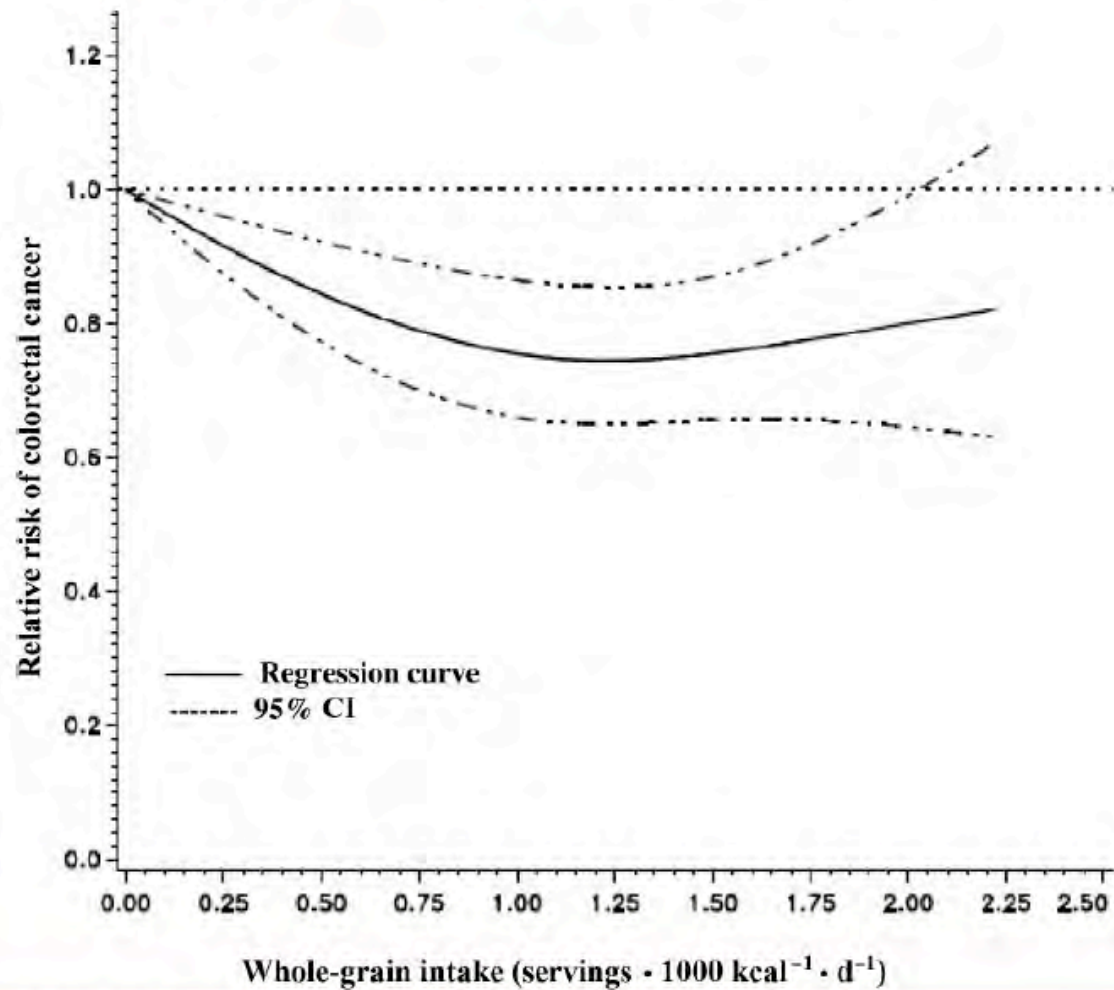
Whole Grains & Type 2 Diabetes: Potential Mechanisms

- Activity of components including fiber, magnesium, vitamin E, phytic acids, phenolic compounds
- Short-chain fatty acids
- Viscous fibers
- Antioxidant activity

Whole Grain Consumption Inversely Associated with Colorectal Cancer Risk*

<u>Study</u>	<u>Relative Risk (95% CI)</u>
Fuchs et al., 1999	1.23 (0.70-1.76)
Pietinen et al., 1999	1.00 (0.64-1.36)
Terry et al., 2001 (Prudent Diet)	0.79 (0.43-1.15)
Terry et al., 2001	0.91 (0.63-1.19)
Bingham et al. 2003	0.78 (0.55-1.01)
Fung et al., 2003 (Prudent Diet)	0.71 (0.35-1.07)
Fung et al., 2003	1.46 (1.05-1.87)
Mai et al., 2003	1.02 (0.73-1.31)
McCullough et al., 2003	1.17 (0.70-1.64)
Bingham et al., 2005	0.93 (0.72-1.14)
Larsson et al., 2005	0.80 (0.51-1.09)
Total	0.94 (0.85-1.03)

Association between whole-grain intake and risk of colorectal cancer



Observational Studies Showing a Benefit of Increased Whole Grain Consumption on Cancer Risk*

Study Data Source	Reported Association/Outcome	Reference
National Institutes of Health and AARP Diet and Health Study (291,988 men and 197,623 women) 5 year follow-up (U.S. population)	14% reduction in colon cancer risk 15% reduction in distal colon cancer risk 36% reduction in rectal cancer risk Trend for reduction in proximal; colon cancer risk	(Schatzkin et al 2007)
National Institutes of Health and AARP Diet and Health Study (293,703 men and 198,618 women) 5 year follow-up (U.S. population)	41% reduction in small intestinal cancer risk	(Schatzkin et al 2008)
Population-based case-cohort study 532 incident cases 1,701 controls (U.S. population)	40% reduction in pancreatic cancer risk	(Chan et al 2007)
Swedish Mamography Cohort (61,433 women over 40 yrs) 14.6 year follow-up (Swedish population)	33% reduction in colon cancer risk	(Larsson et al 2005)

*Only significant differences are reported unless otherwise stated ($P < 0.05$) for fully adjusted models.

Relative Risks of Small Intestinal Cancer by Quintiles of Dietary Fiber and Whole Grain Intakes

	Quintile of intake					<i>P</i> trend
	1	2	3	4	5	
Whole grain (svgs/1,000 kcal)	<0.3	0.3-<0.5	0.5-<0.7	0.7-<1.0	≥1.0	
Cases/ person years	39/670,289	34/675,902	41/677,448	29/677,897	22/678,431	
Relative Risk	1.0	0.86	1.03	0.73	0.59	p<0.06
Fiber from grains (g/day)	<3.7	3.7-<5	5-<6.4	6.4-<8.4	≥8.4	
Cases/ person years	34/675,077	41/677,599	32/676,861	37/675,221	21/675,209	
Relative Risk	1.0	1.10	0.81	0.91	0.51	p<0.01



Whole Grains & Cancer: Potential Mechanisms

Gastrointestinal

- Carbohydrate fermentation
- Decreased transit time and increased fecal bulk
- Antioxidant activity
- Glucose/insulin response

Whole Grains & Total Mortality: Epidemiological Studies

Harvard Male Health Professionals (86,000)

1 or more serving/day
of whole grain cereal
(compared to none)



Mortality
RR 0.80

Iowa Women's Health Study (34,333)

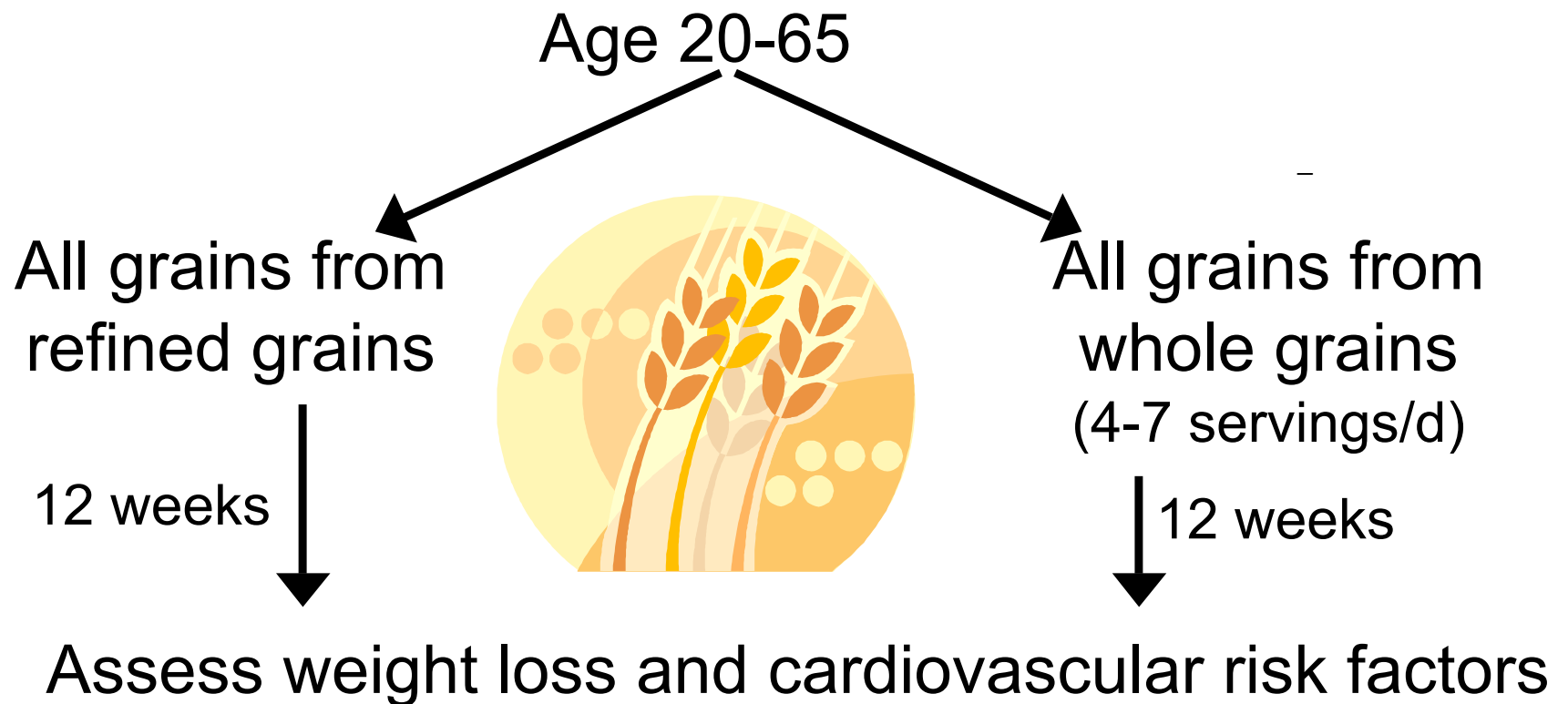
3 or more servings/day
of whole grain foods



Hazard
RR 0.86

Whole Grain Intake and Weight Loss: Study Design

50 men and women with metabolic syndrome



Inclusion Criteria



1. Men and women with a BMI ≥ 30 kg/m²
2. Have at least 3 ATP III criteria for metabolic syndrome:
 - Abdominal obesity (elevated waist circumference)
 - Men ≥ 102 cm; Women ≥ 88 cm
 - Raised triglycerides (≥ 150 mg/dL)
 - Reduced HDL cholesterol
 - Men < 40 mg/dL; Women < 50 mg/dL
 - Raised blood pressure ($\geq 130/$ or ≥ 85 mmHg)
 - Elevated plasma glucose (≥ 100 mg/dL)
3. Not taking any medications known to affect glucose tolerance, lipids, or reproductive hormones

Endpoints



- Weight loss * Primary Endpoint
- Lipids and Lipoproteins
 - Cholesterol, HDL, LDL, VLDL, triglycerides
- Inflammation
 - C-reactive Protein, IL-1, IL-6, TNF- α
- Waist Circumference & Abdominal Adiposity
- Glucose Tolerance
 - Glucose & insulin response to an OGTT
- Diet Satisfaction

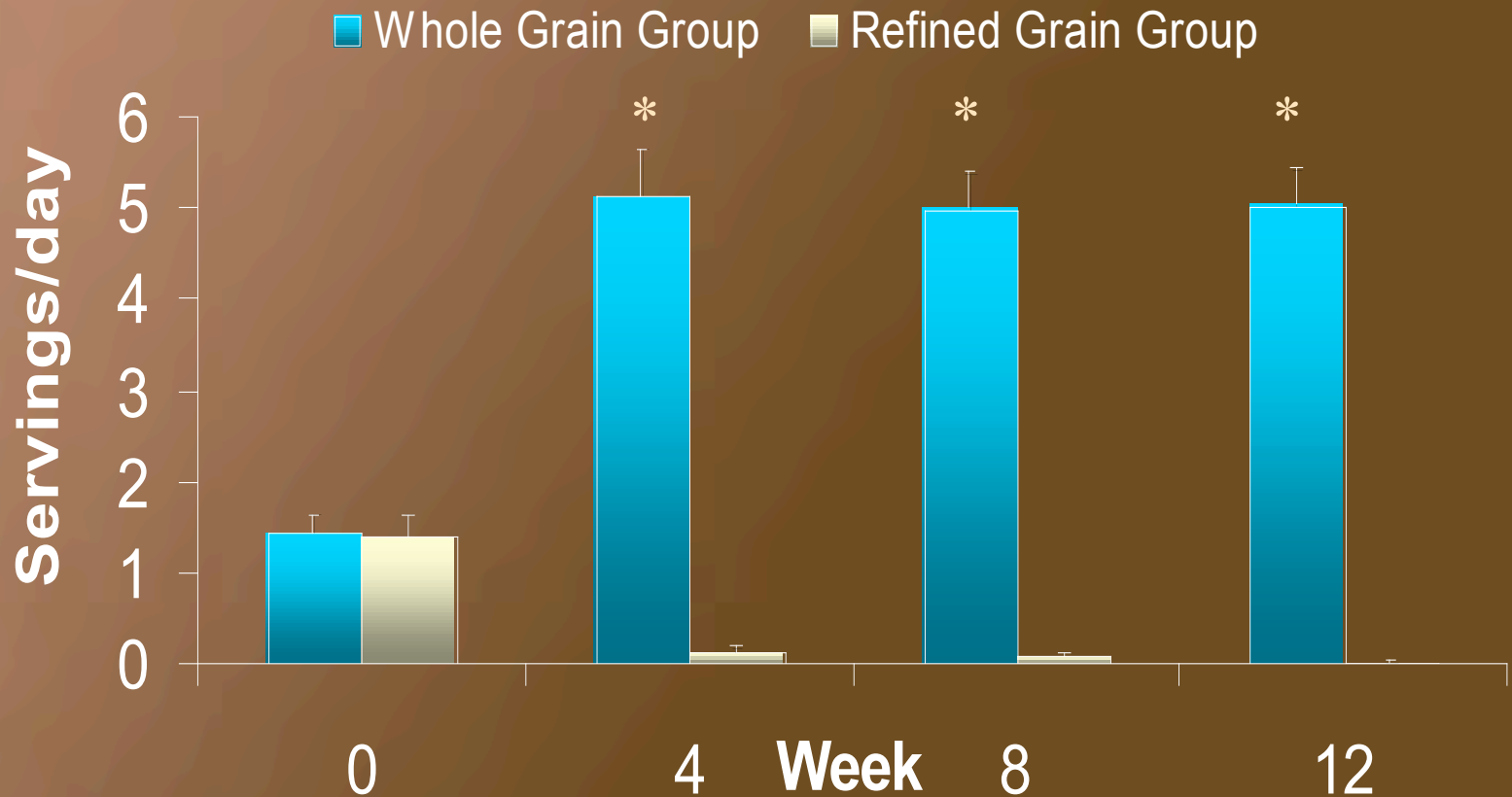
Baseline Characteristics



	<u>Whole Grain</u>	<u>Refined Grain</u>
	12M, 13F	13F, 12M
Age (y)	45 ± 8	47 ± 10
BMI (kg/m ²)	36 ± 4	36 ± 5
Waist Circ (cm)	117 ± 12	118 ± 10
LDL (mg/dL)	119 ± 39	115 ± 20
HDL (mg/dL)	41 ± 9.0	41 ± 8.0
Tgl (mg/dL)	146 ± 63	162 ± 65
Glucose (mg/dL)	96 ± 8	96 ± 6
Insulin (μU /mL)	15 ± 8	14 ± 7
Systolic BP (mmHg)	123 ± 9	130 ± 13 *
Diastolic BP (mmHg)	82 ± 8	83 ± 8

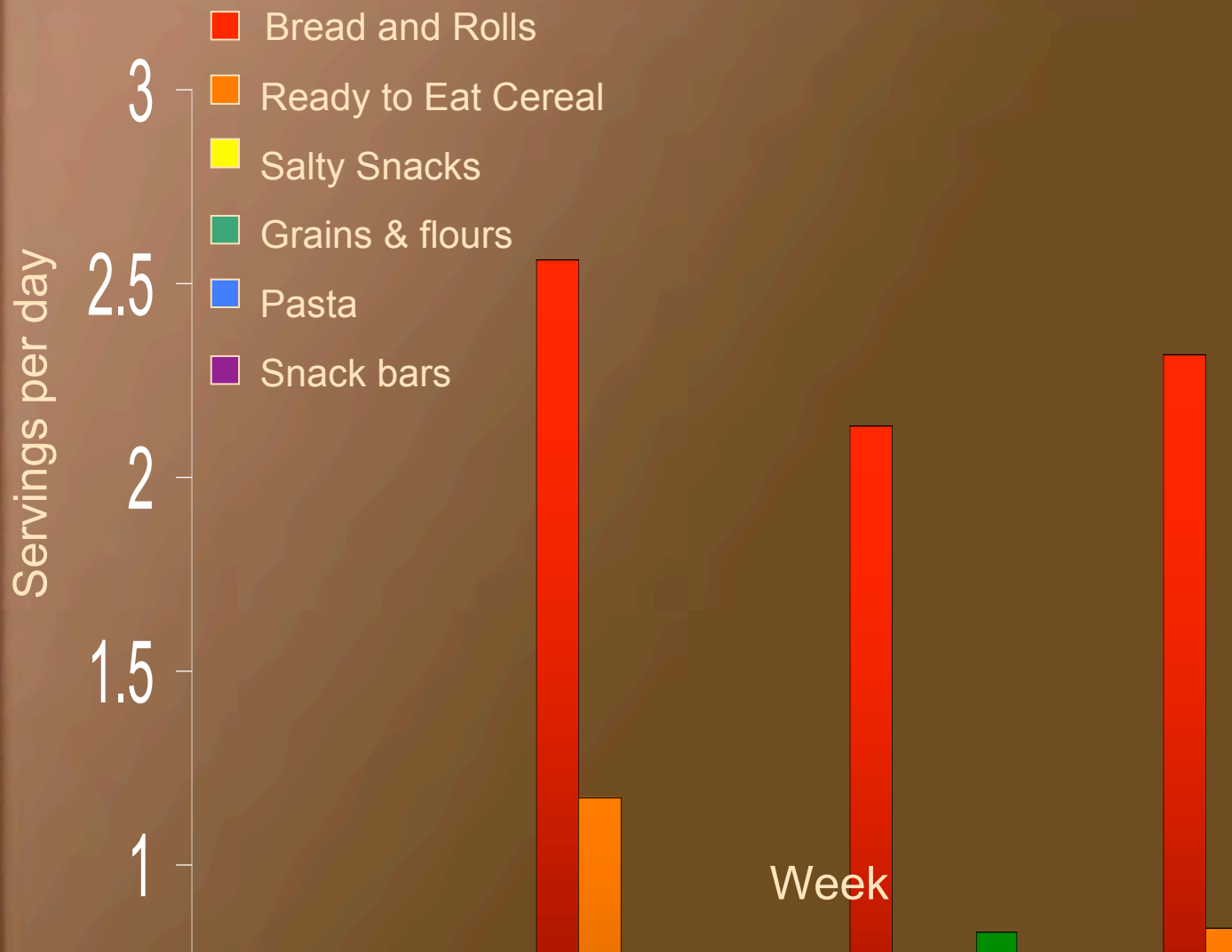
Values are Mean ± SD. * P < 0.05 difference between groups

Both groups complied with whole grain recommendations

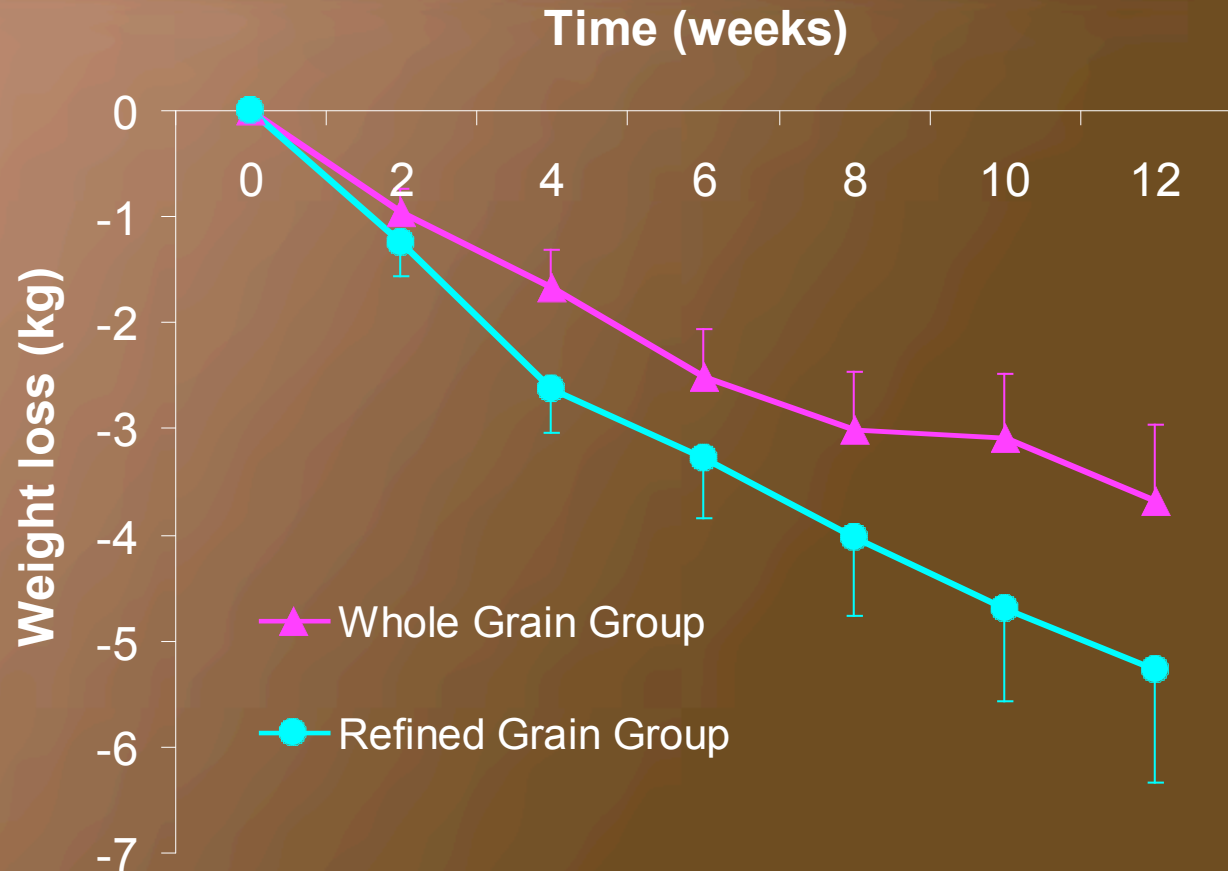


* $P < 0.001$ difference between groups. Values are mean \pm SE.

Sources of whole grain foods in the whole grain group

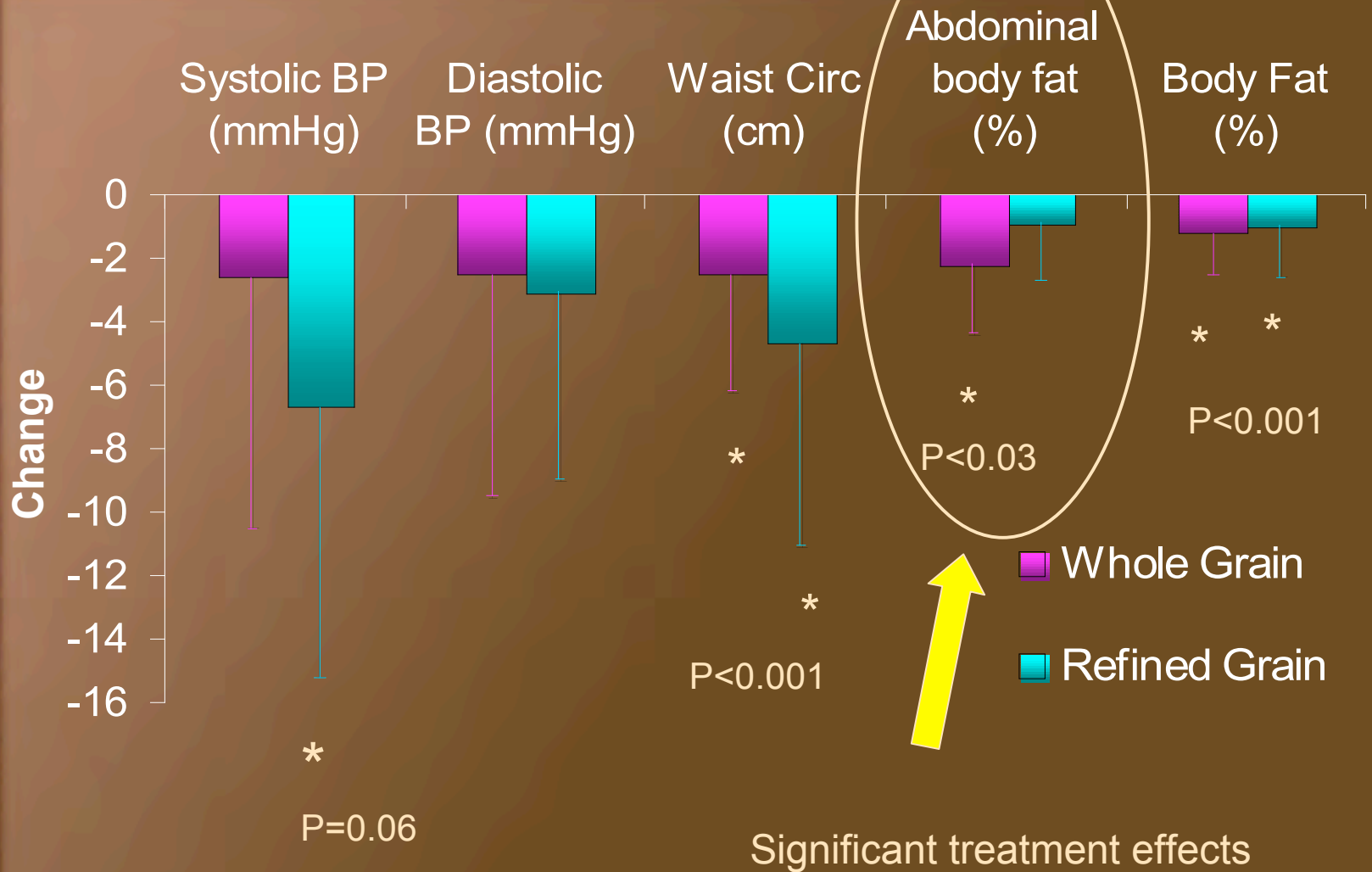


Body weight decreased in both groups

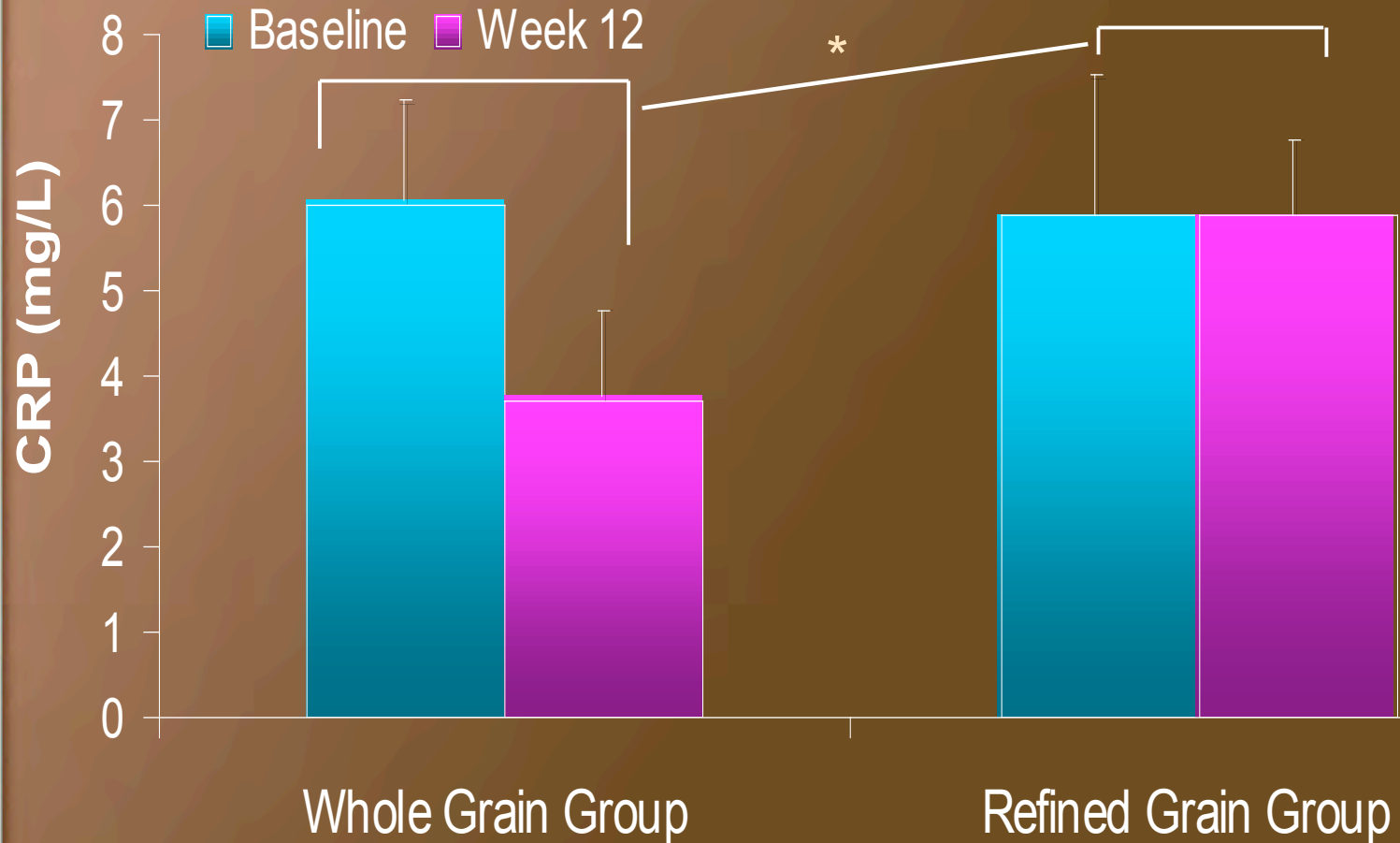


No significant difference between groups in weight loss at any time point

Improvements in other biometric measurements

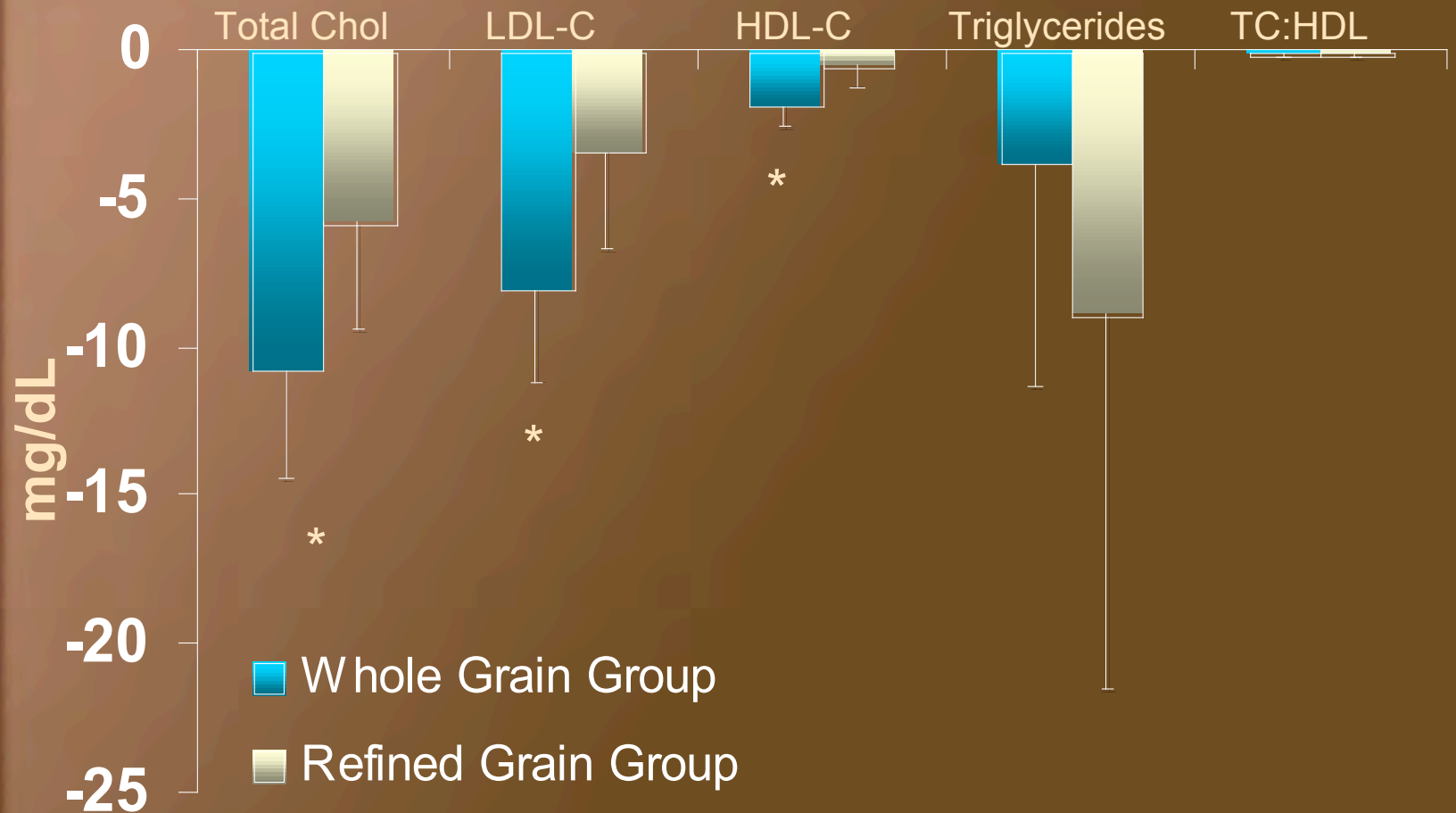


C-reactive protein decreased in the whole grain group only (by 38% vs baseline)



* $P = 0.007$ different between groups. Values are mean \pm SE.

No significant difference between groups in lipids and lipoproteins



* $P < 0.05$, different from baseline. Values are mean \pm SE.

The “Whole” Truth



- Consuming whole grains was associated with improved diet quality
- No significant difference in weight loss between a whole grain and refined grain diet
- Greater reduction in C-reactive protein in participants in the whole grain group
- Greater reduction in percentage body fat in the abdominal region in the whole grain group
- No significant differences between groups in change in lipids and lipoproteins or glucose tolerance

Benefits of Whole Grains Go Beyond Fiber

Bran

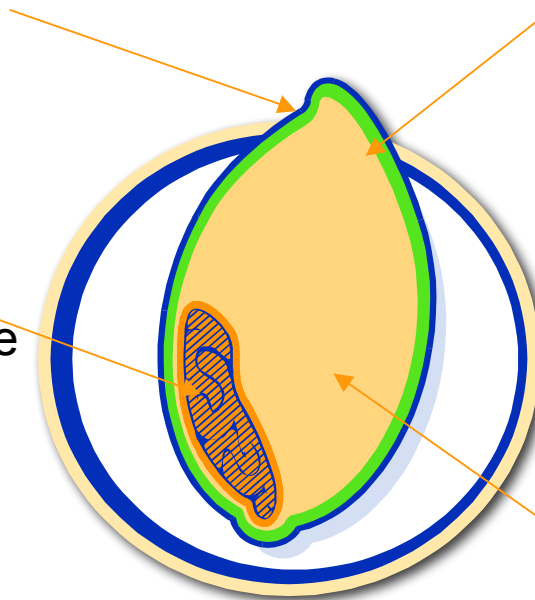
“Outer shell” protects seed

- Fiber
- B Vitamins
- Trace Minerals
- Phytochemicals

Germ

Nutrient storehouse

- B Vitamins
- Vitamin E
- Trace Minerals
- Phytochemicals
- Antioxidants
- Lipids
- Healthy Fats



Aleurone

Layer of cells adjacent to endosperm

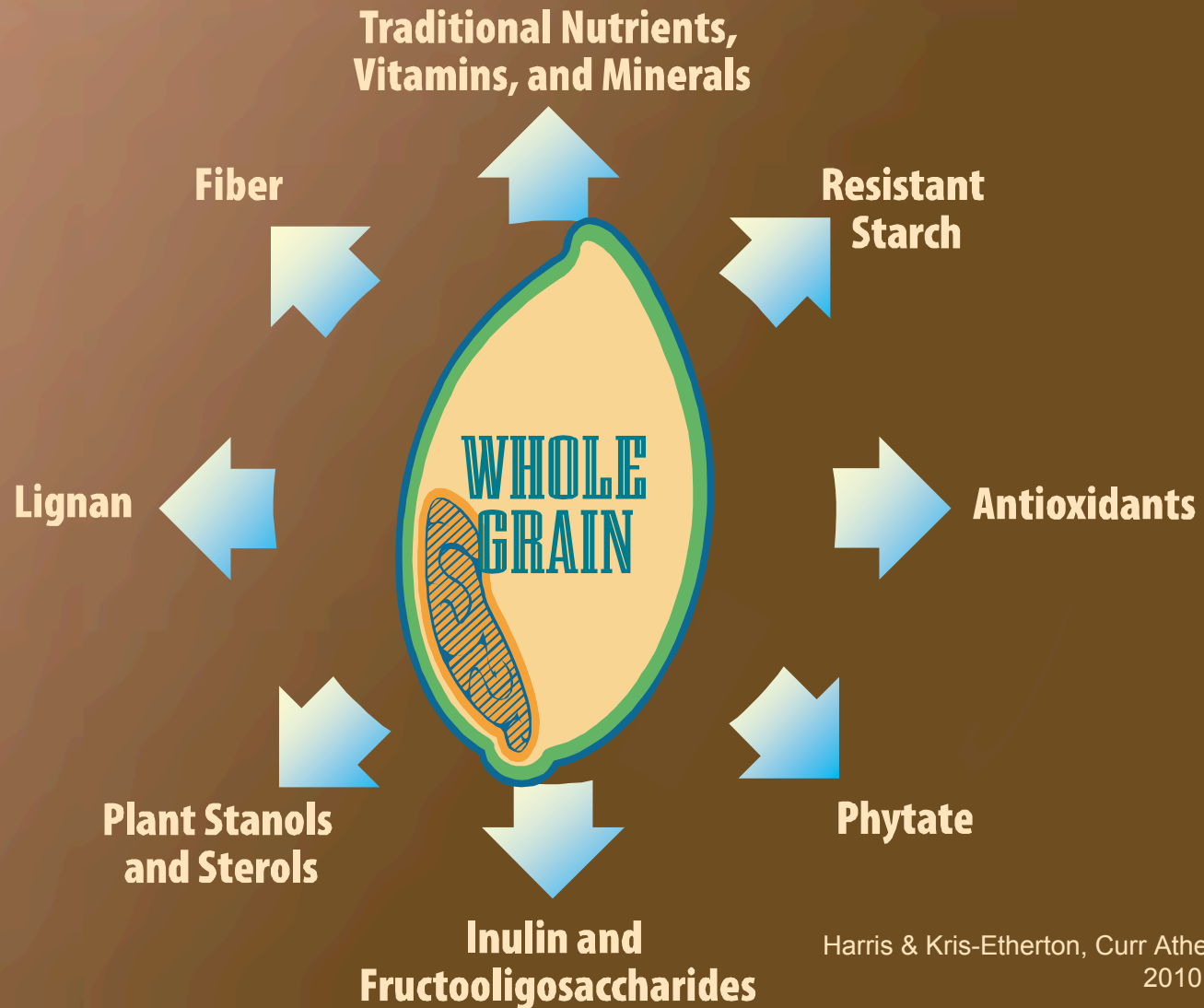
- Protein
- Enzymes
- Fiber
- Phytochemicals

Endosperm

Provides energy

- Carbohydrate
- Protein
- Some B Vitamins

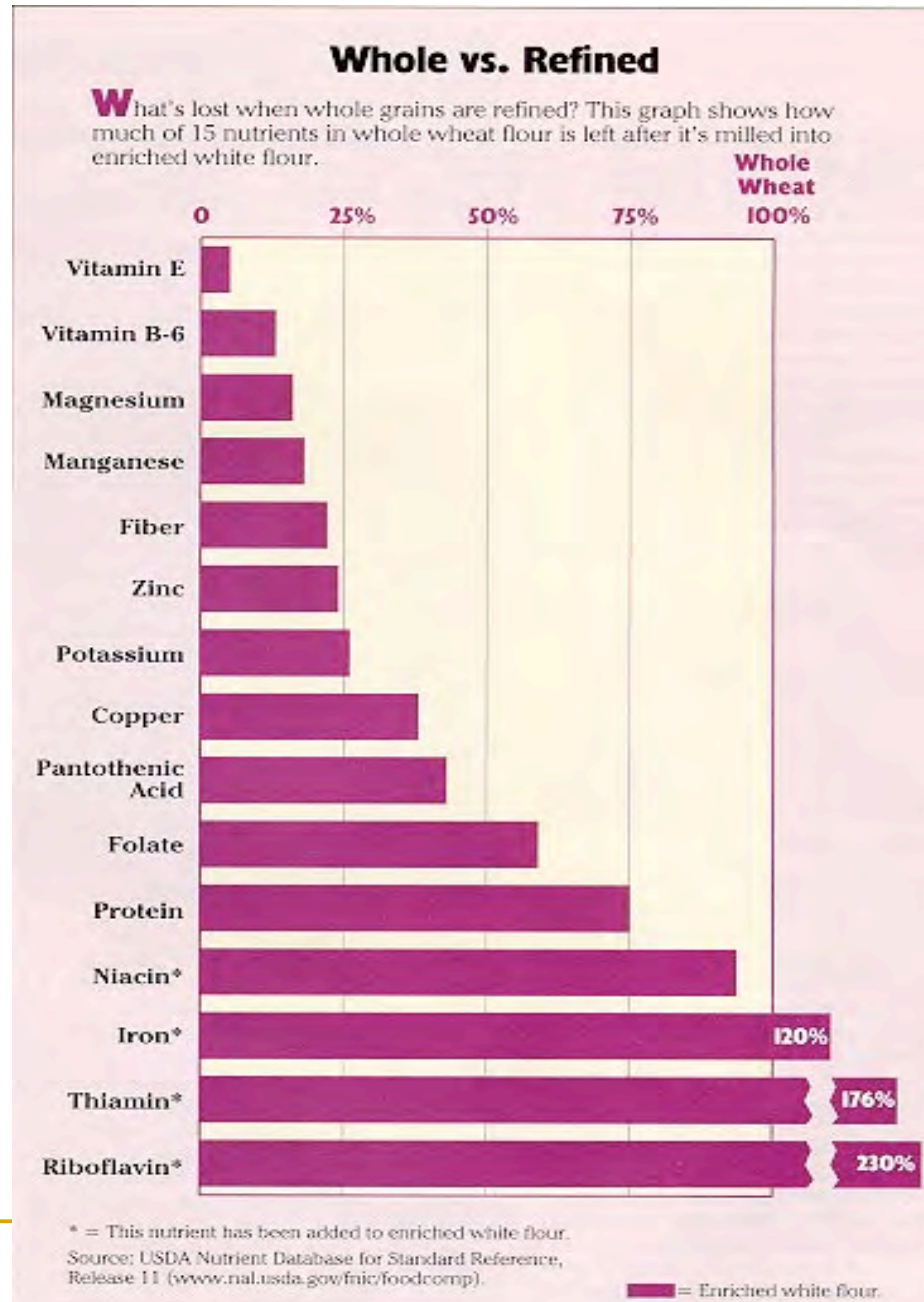
Whole Grains Have Benefits Beyond Fiber



Harris & Kris-Etherton, *Curr Atheroscler Rep.* 2010;12:368-376.

Phytonutrients

- Small but powerful disease fighters found naturally in plant and plant-based foods.
- Whole grains contain significant amounts of the phytonutrients lignan, phytic acid, and phytosterols.
- Aim to get a variety of whole grains in your diet—that way you're more likely to get all of the phytonutrients your body needs!





Whole Grain Recommendations

Recommendations

- The 2005 Dietary Guidelines recommends 3 or more servings of whole grains per day
- DGAC 2010 recommends increasing consumption of fiber-rich whole grains
- *Healthy People 2010* objectives aim for 3 servings/day
- American Diabetes Association, 2011 recommends foods containing whole grains (1/2 of grain intake)
- AHA, 2020 Goals - Fiber-rich whole grains (1.1 g of fiber per 10 g of carbohydrate): three 1-oz-equivalent servings per day

The Whole Grain Consumption Gap

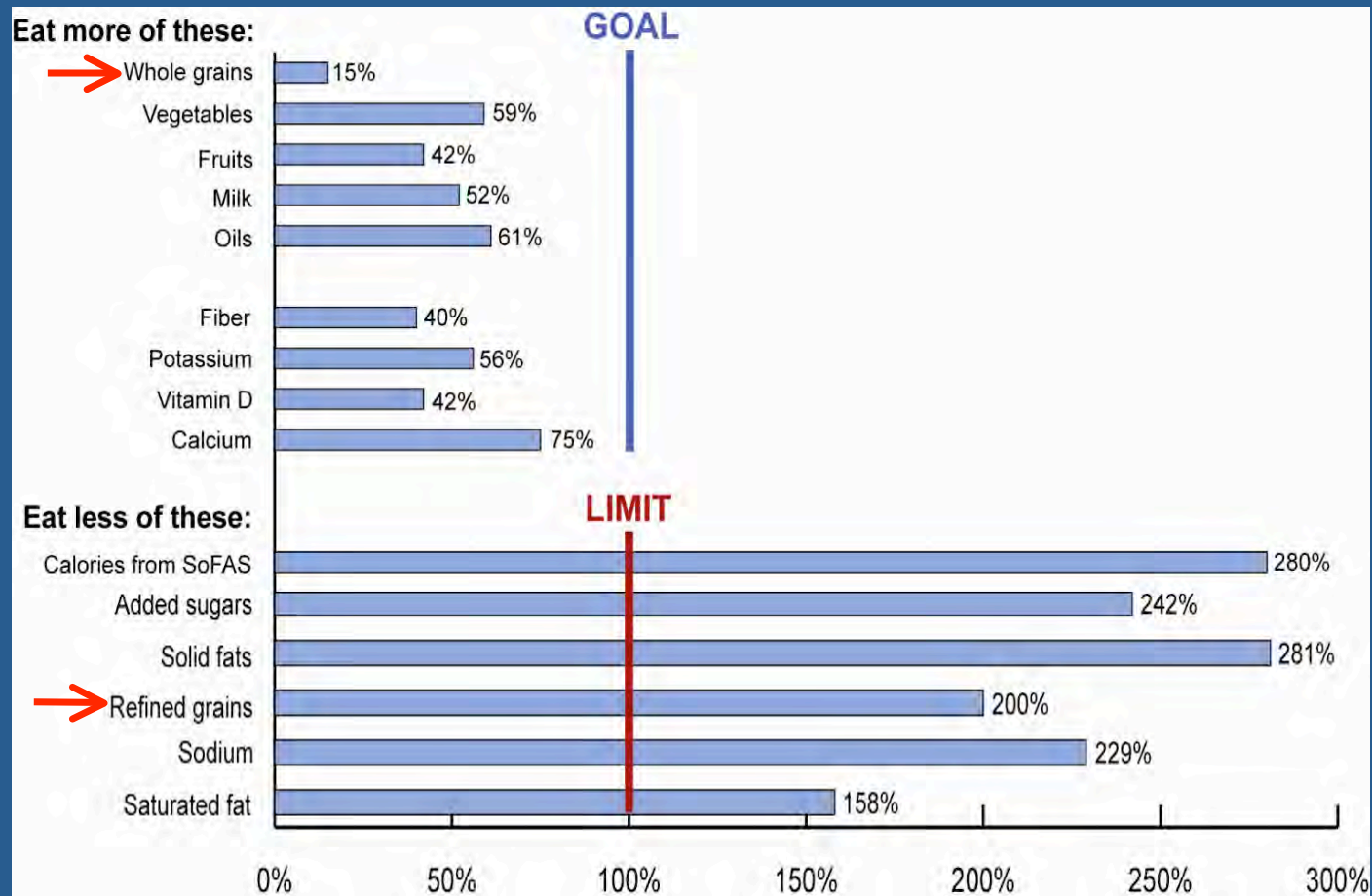
Average whole grain intake is less than 1
serving/day

NHANES 1999-2002

9/10 Americans not eating 3 sv/d whole
grains



Dietary Intakes Compared to Recommended Intakes



Intake as percent of goal

Conclusions

- Scientific evidence supporting the health benefits of whole grains continues to grow
- Scientific support of the health benefits of whole grains is ***strong and consistent***, based on the totality of the evidence
- Health benefits of whole grains are attributed to **all parts** of the whole grain - bran, germ, and endosperm



Consume Fiber-Rich Whole Grains!

