Whole Grain & Weight Management:

an overview of the evidence

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HARLAND HALL

Outline

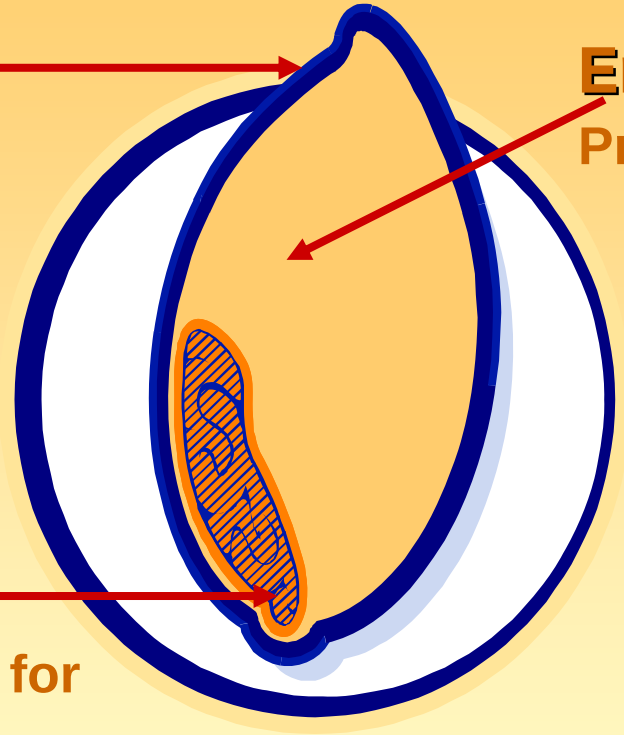
- Definitions of whole grain, healthy weight & adiposity
- Extent of overweight and obesity in Europe
- Systematic review
- Epidemiological evidence
- Clinical evidence
- Mechanisms
- Other health benefits
- Dietary recommendations
- Conclusions

When is a grain “whole”?

Bran

“Outer shell” protects seed

- **Fiber**
- **B Vitamins**
- **Trace Minerals**



Endosperm

Provides

- **Energy**
- **Carbohydrate**
- **Protein**
- **Some B Vitamins**

Germ

Nourishment for the seed

- **B Vitamins**
- **Vitamin E**
- **Trace Minerals**
- **Phytochemicals**

“whole” grain?

But we hardly ever eat grain whole....

... it is usually processed into flour or food ingredient for breakfast cereals, pasta

Definitions: healthy weight

- BMI = $\frac{\text{Weight (kgs)}}{\text{Height (m)}^2}$
  - Ideal range 20 -25
  - Overweight ≥25 -30
  - Obesity ≥30

Definitions: healthy weight

ıgd (m)	40	45	50	55	60	65	70	75	80	85	90	95
1.50	18	20	22	24	26	29	31	33	35	38	40	42
1.55	17	19	21	23	25	27	29	31	33	35	38	40
1.60	16	18	20	21	23	25	27	29				37
1.65	15	17	18	20	22	24	26	28	29	31	33	35
1.70	14	16	17	19	21	22	24	26	28	29	31	33
1.75	13	15	16	18	19	21	23	25	26	28	29	31
1.80	12	14	15	17	18	20	22	23	25	26	28	29
1.85	11	13	14	16	17	19	20	22	23	25	26	28
1.90	11	12	13	15	16	18	19	20	22	23	25	26

Obese

Overweight

Ideal

Definitions: central adiposity

- Waist circumference

Three categories:

	healthy	overweight	obese
Men:	<94cm	94 -<102cm	≥ 102cm
Women:	<80cm	80 -<88cm	≥ 88cm

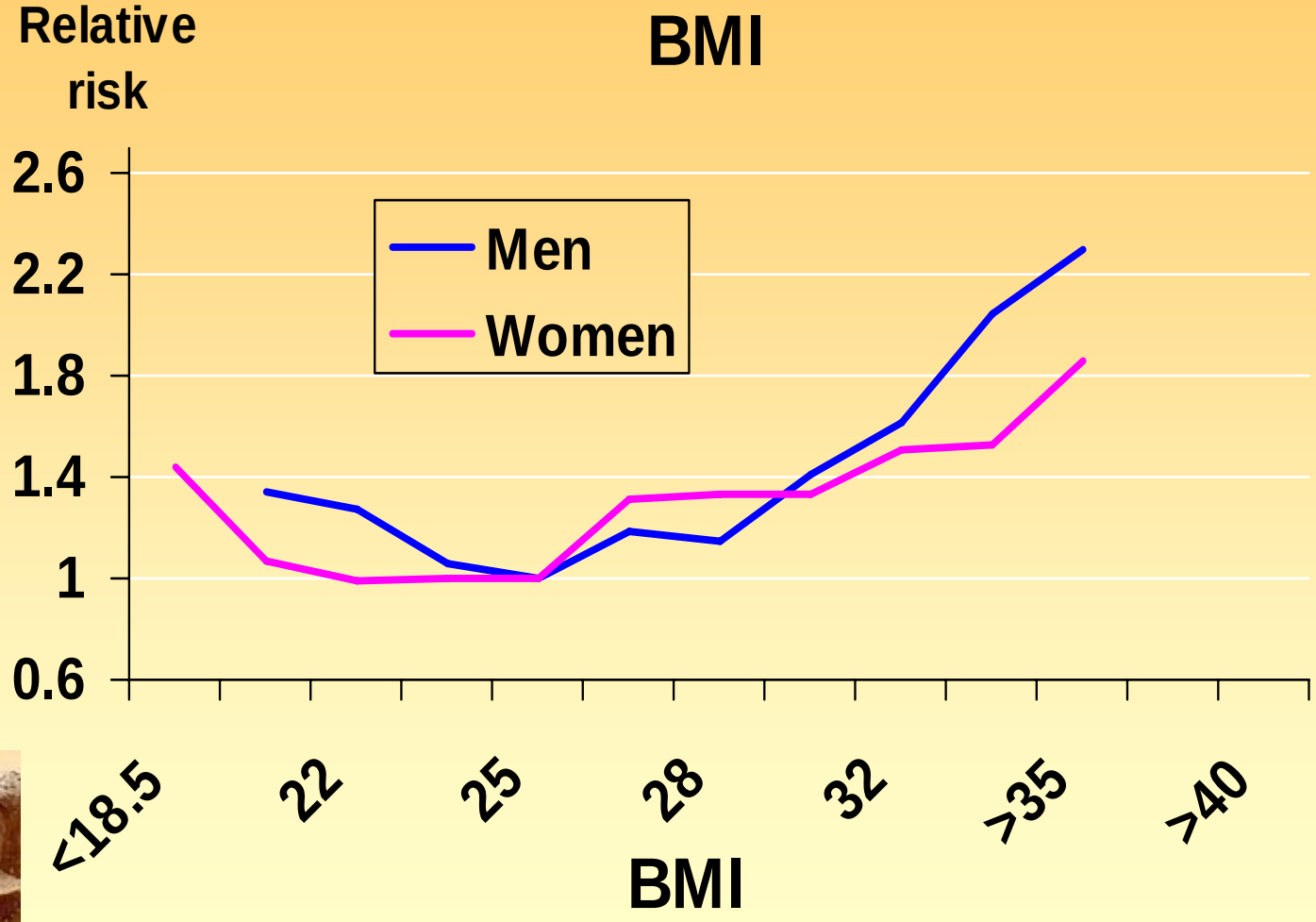
- In the UK the higher two categories have been designated "action levels" 1 and 2 corresponding to slightly increased & substantially increased risk of chronic conditions such CVD and diabetes

Weight management: Why?

- Adults in Western world are getting fatter…
  - Globally, there are more than 1 billion overweight adults, at least 300 million of them obese (WHO).
  - Obesity and overweight pose a major risk for chronic diseases, including type 2 diabetes, cardiovascular disease, hypertension and stroke, and certain forms of cancer.
  - Key causes are increased consumption of energy-dense foods high in saturated fats and sugars, and reduced physical activity.

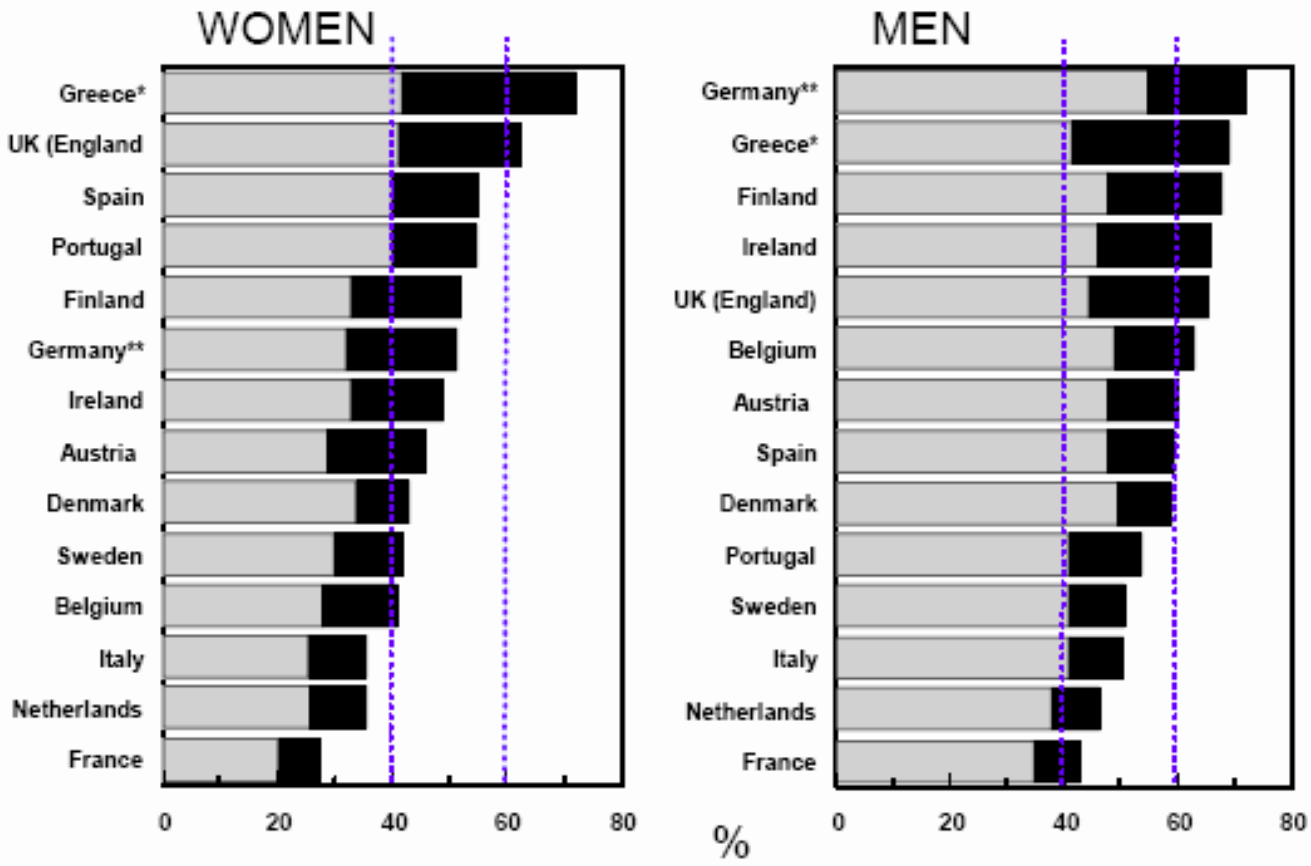
Source: WHO, Global Strategy on Diet, Physical Activity and Health

Relative risk of death according to BMI



After Calle *et al* 1999

Fig 1a Estimated EU country prevalence of overweight and obesity



* Restricted age group
**Germany overweight figures derived from WHO MONICA studies

BMI 25-29.9

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Source: 2002

International Obesity TaskForce +

European Association for the Study of Obesity

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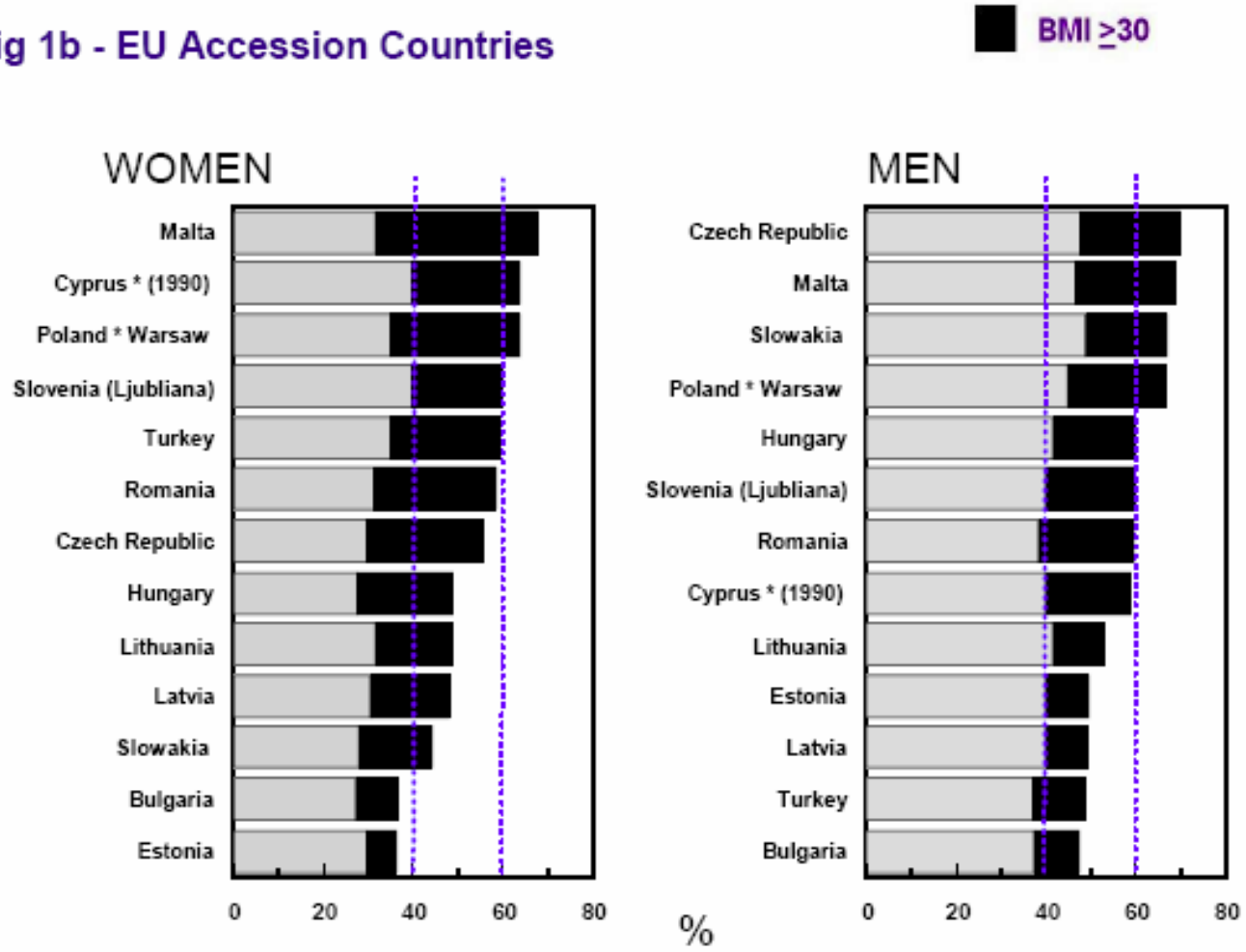
Fig 1b - EU Accession Countries



Source: 2002 International Obesity TaskForce + European Association for the Study of Obesity

Examples of cost of obesity:

Country	Cost	% Health Expenditure
UK (1995)	816 (+3270 indirect)	1.5%
France (1992)	640-1320	1.5%
Germany (1996)	106000	na
Portugal (1996)	230	3.5%
Netherlands (1981-1989)	454	4%
USA	70,000U$	7%

Source: IOTF collated data converted 2002 (unadjusted for inflation)

Dietary approaches

- WHO guidelines... promote healthy behaviours to encourage, motivate and enable individuals to lose weight by eating more fruit and vegetables, as well as nuts and whole grains.

SOURCE: WHO Recommendations for preventing excess weight gain and obesity, p61-71.: www.who.org, 2003.

Summary of strength of evidence on factors that might promote or protect against weight gain and obesity

Evidence: Decreased risk	No relationship	Increased risk
Convincing		
Regular physical activity High dietary intake of NSP (dietary fibre)		Sedentary lifestyles High intake of energy -dense micronutrient-poor foods
Probable		
Home and school environments that support healthy food choices for children Breastfeeding		Heavy marketing of energy-dense foods and fast-food outlets High intake of sugars-sweetened soft drinks and fruit juices Adverse socioeconomic conditions (in developed countries, especially for women)
Possible		
Low glycaemic index foods	Protein content of the diet	Large portion sizes High proportion of food prepared outside the home (developed countries) ‘‘Rigid restraint/periodic disinhibition’’ eating patterns Alcohol
Insufficient		
Increased eating frequency		

Based on the totality of the evidence. The World Cancer Research Fund 2002

WG and weight management: Review of evidence[1]

Objective

To review the literature relating to WG to determine the effect on measures of body weight and adiposity

Design

Systematic review & meta analysis of observational studies

Method

Search Medline and Embase, SciSearch, Current Contents
Hand searches of key papers, publications & reference lists in identified papers from 1990 to December 2006.

Search terms

"WHOLEGRAIN or WHOLE GRAIN" and "OBESITY or BODY WEIGHT or BMI or BODY FAT" in Medline (inc "BODY MEASURES).

Inclusion criteria

Cohort and X sectional studies that reported measure of weight management or adiposity and intake of WG.

[1]Based on Harland JI and Garton LE. *Public Health Nutr* 2008; **11**: 554-63.

WG and weight management: systematic review

Primary Outcomes

- Effect of a higher WG intake on BMI, WC or W:HR & weight gain
- Effect of higher WG intake on lifestyle/dietary factors

Quality assessment

- Studies reviewed by both JH and LG, data abstracted and subject to quality assessment in 3 main areas:
  - Recruitment & flow of subjects through study
  - Dietary assessment including WG definition
  - Data treatment & reporting

Statistics

- Estimates of mean effect on BMI, WC or W:H ratio in highest (ca 3 servs) and lowest WG intake groups
- Overall effect size calculated by weighting each study by the reciprocal of the total variance for change.
- Fixed and random effects models used
- Heterogeneity tested (Hodge's and Cohen's coefficients).
- Plots of pooled effects
- Funnel plots used to assess publication bias

WG and weight management: systematic review

Results

- Total studies identified:115
- Retained:
  - 11 X sectional studies
  - 5 cohorts + 1 cohort intervention
- Further analysis:
  - 15 observational trials;
  - 20 intervention arms in total (n=119,829)

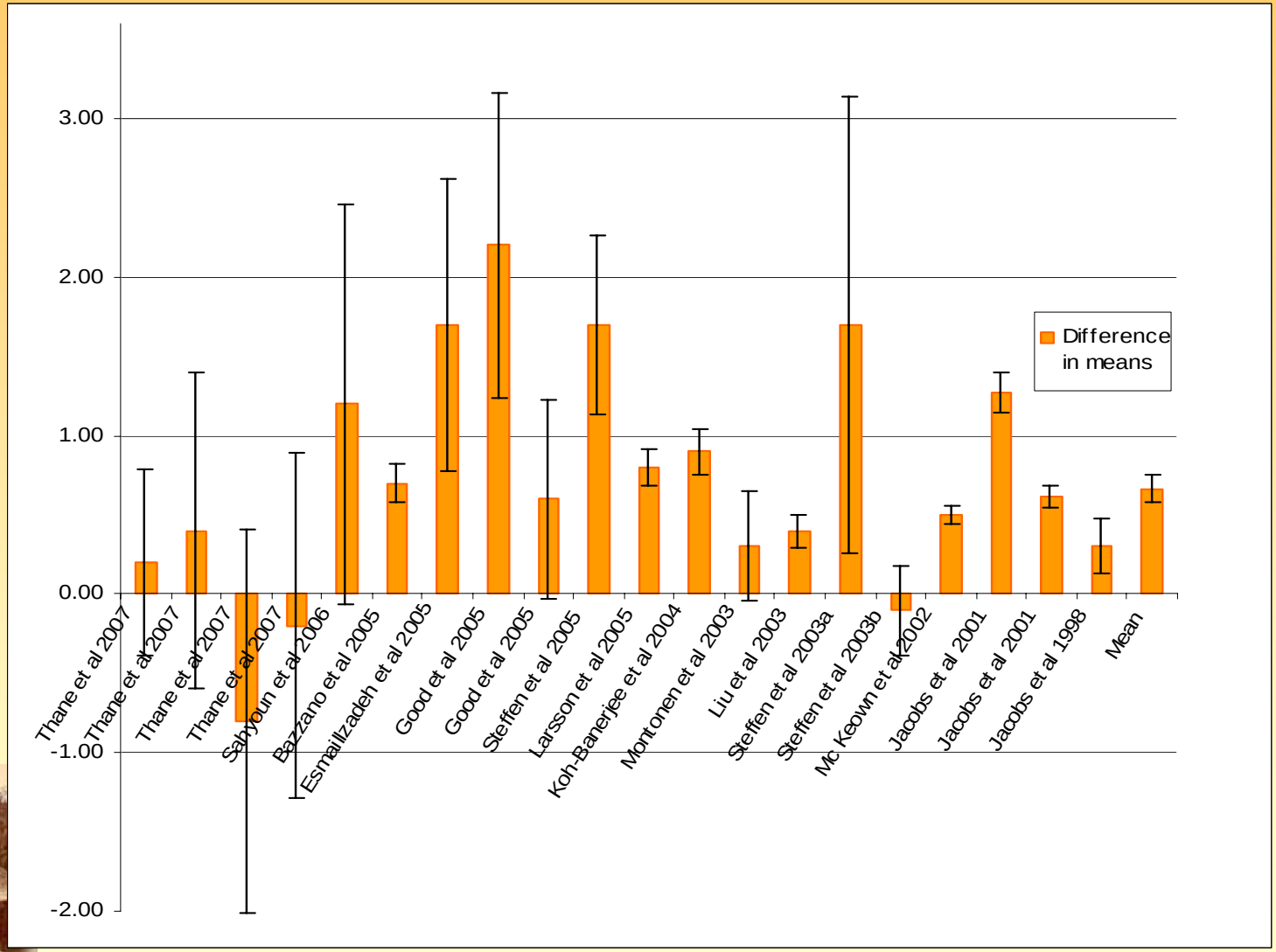
Study Population characteristics

- WG most frequently defined by Jacobs ($\geq$25%WG)
- 13 studies reported some dietary intake data
- 15 treatment arms where WG intake *ca* $\geq$3
- Study population:
  Age range was 13 to 98y;
  Male n=34075; female n= 75059

WG and BMI - X sectional studies

Study Country	Sex Age	Description	Highest intake of WG
Thane *et al* 2007 UK	M/F 16-64	**NDNS** 1986/7 base 2197 & **NDNS** 2000-1 base 1724 Analysis of two distinct surveys	>48g
Sahyoun *et al* 2006 USA	M/F 60-98	Community persons > 60yrs from Boston MA, base 1981:4 747	2.9serv
Bazzano *et al* 2005 USA	M 40-84	**Physicians Health Study** base 22071 in 1982	>1
Esmaillzadeh *et al* 2005 Iran	M/F 18-74	Tehran Lipid and Glucose Study (TLGS) base 861 at screening	229g foods
Good C K *et al* 2005 USA	M/F 19+	**USDA Continuing Survey of Food Intakes** by Individuals (CSFII) pyramid servings database 1994-6	>3 servs
Larsson *et al* 2005 Sweden	F 40-76	**Swedish Mammograph Cohort** established 1987-1990 base 66651	5 servs
Steffen *et al* 2005 USA	M/F 18-30	Coronary Artery Risk Development in Young Adults (**CARDIA**) Study. Base 1985-6: 4304.	>1.9 times/day
Koh-Banerjee *et al* 2004 USA	M 40-75	**Health Professionals Follow-Up Study** (HPFS) 1986 Base 51529 made up of dentists, vets, pharmacists etc.) data reported for 1994	45.8g
Liu *et al* 2003 USA	F 38-63	**"Nurses Study"** 1984 Base 81757	3.1serv
Montonen *et al* 2003 Finland	M/F 40-69	Finnish Mobile Clinical Health Examination Survey in 1966-72 baseline 4316	302g
Steffen *et al* 2003a USA	M/F 13/ 12.9	Minneapolis students aged 13-15, 357 screened, baseline 285, who completed 2 insulin clamp studies	2.6 serv
Steffen *et al* 2003b USA	M/F 45-64	**Atherosclerosis Risk in Community** (ARIC) study, Minneapolis, at screening 15792	3 servs
McKeown *et al* 2002 USA	M/F 54	**Framingham Offspring Study** 3799 at 5th examination cycle 1991-1995.	2.9 servs
Jacobs *et al* 2001 Norway	M/F 35-56	**Norwegian County Study** 41174 at systematic baseline screening 1977-1983	2.25-5.40 WG score
Jacobs *et al* 1998 USA	F 55-69	**Iowa Women's Health Study** (IWHS), 41836 at screening	3.2 servs

X sectional studies: BMI and WG intake



Random effects model: heterogeneity = P>0.01

Source: Harland JI and Garton LE, 2008 PHNutr

X sectional studies: BMI and WG intake

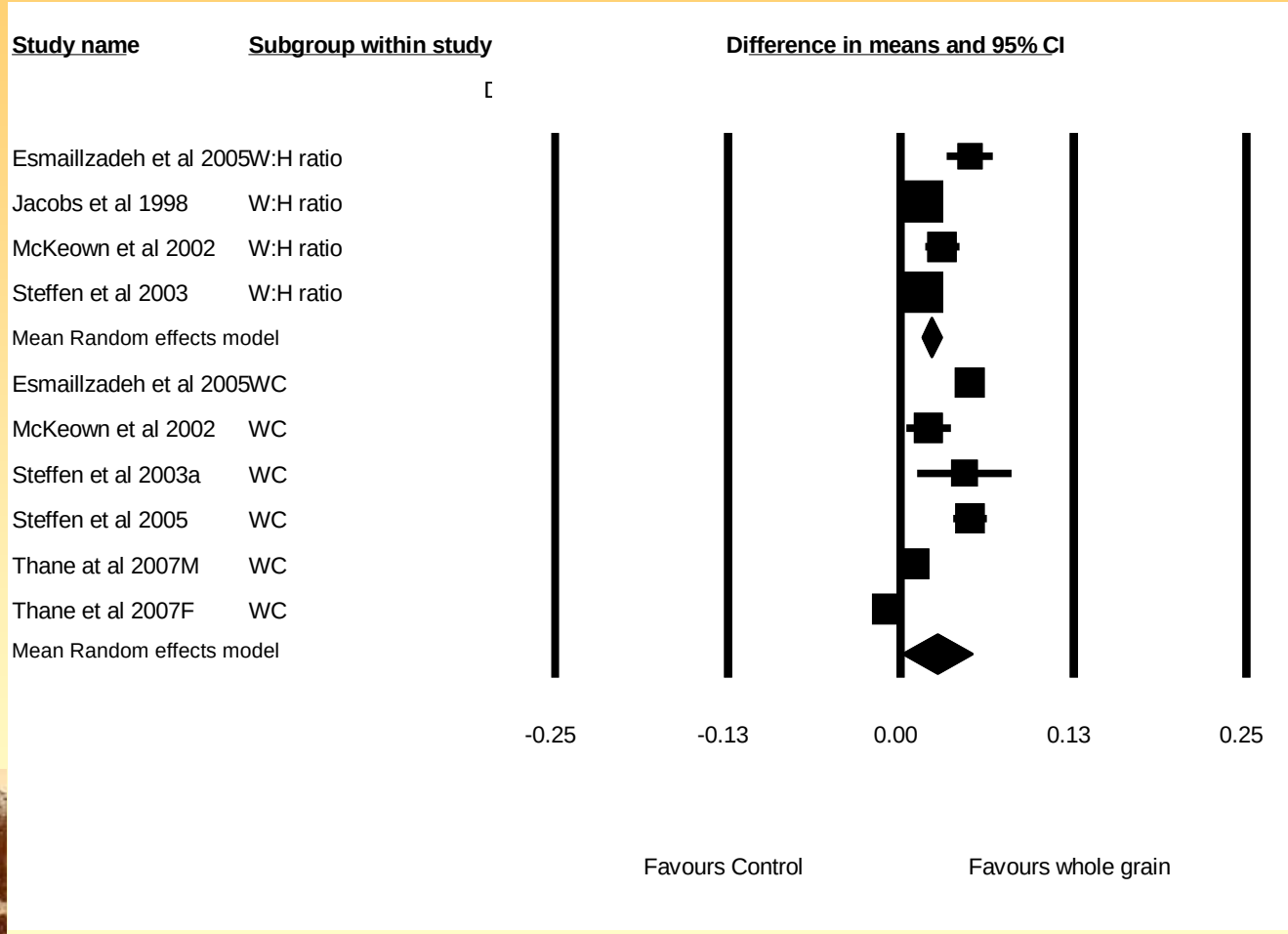
- Mean difference in BMI = 0.665 kg/m^2
  (95% CI 0.490-0.839), *P*>0.0001
  Results from 15 studies (20 treatment arms)(n=119,829)

  Sub analysis:
  - Mean difference in BMI - Males = 0.671 kg/m^2 *P*>0.0001
  - Mean difference in BMI - Females =0.695 kg/m^2 *P*>0.0001

  - Mean difference in BMI - N America = 0.704 kg/m^2 *P*>0.0001
  - Mean difference in BMI - Europe = 0.570 kg/m^2 *P*>0.0001

Source: Harland JI and Garton LE, 2008 PHNutr

WG intake and central adiposity



Source: Harland JI and Garton LE, PH Nutr 2008

Effect of WG intake on adiposity

- Higher WG intake, waist circumference 2.7cm less (95% CI 0.2-5.2), *P*=0.03 (6 datasets, n=4178)

  Waist:hip ratio 0.023 lower (95% CI 0.016-0.030), *P*>0.0001 (4 datasets, n=20147)

Source: Harland JI and Garton LE, 2008 PHNutr

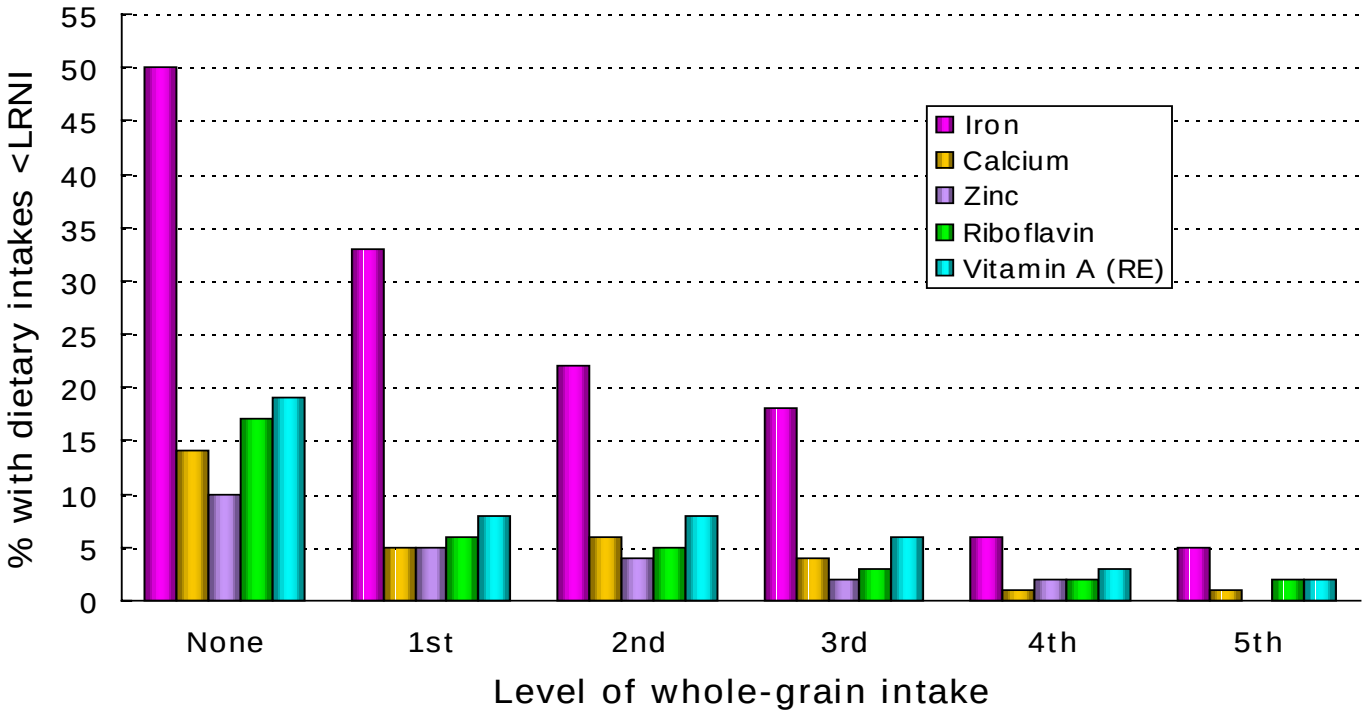
Effect of WG intake on nutrient intake and lifestyle factors

- Higher WG grain intake led to 9g increase in dietary fibre (*P*>0.01)
- Total and saturated fat reduced by 11g and 3.9g
- Smokers 29.8 v 17.4% (P=0.02)
- Regular exercise 40.1 v 51.5%

Source: Harland JI and Garton LE, 2008 PHNutr

Other aspects of health - nutrient density

Percentage of women aged 19-64y with selected micro-nutrient intakes <LRNI



"None" indicates no whole-grain intake/kg body weight/d (*n*=232), "1st" to "5th" (each *n*=130-131) indicates increasing fifths of whole-grain intake/kg body weight/d.

Source:MRC Human Nutrition Unit

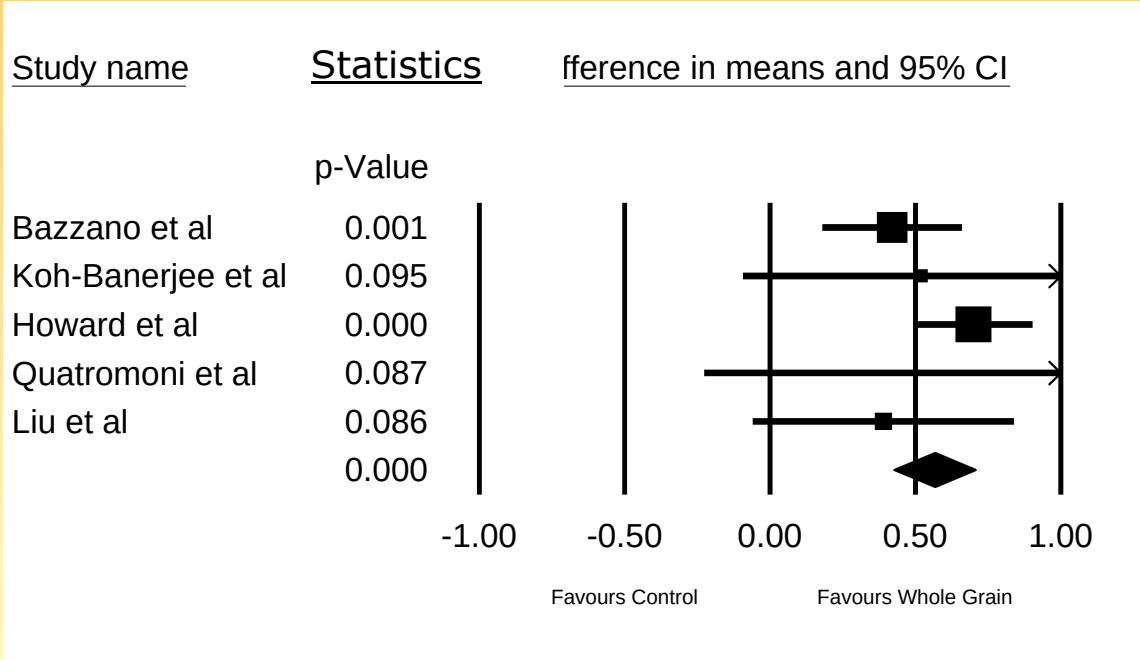
WG and weight gain - Cohort studies

Study	Sex Age	Title Base, Diet Info, Follow-up period	WG intake lowest v highest
Howard *et al*, 2006.	F 50-79	**Women Health Initiative** (WHI) Dietary Modification Trial Base 48835, FFQ. Subjects. Follow-up 7.5 yrs	**16 v 19.2**
Koh-Banerjee *et al,* 2004	M 40-75	**Health Professionals Follow-Up Study** (HPFS) Base 1986, 27082 subjects in analysis, FFQ. Follow-up 8 yrs	**3.0 v 42.7**
Liu *et al,* 2003	F 38-63	**"Nurses Study"** Base 1984 of 74091 Subjects, FFQ Follow-up 12 yrs	**1.9 v 45.1**
Bazzano *et al,* 2005	M 40-80	**Physicians Health Study** (PHS) Breakfast cereals only, FFQ Follow-up 8, 12 yrs	**0 v >1**
Quatromoni *et al,* 2006	M/F	**Framingham Offspring Cohort**	**0.13 v 2.9**
Van ver Vijers *et al,* 2005	M/F 55-69	**Netherlands Cohort** FFQ, Follow-up 5yrs	**0 v 9**

Subjects n=207628

Source: Harland JI, Mc Keown NM and Garton LE, unpublished

WG and weight gain - Cohort studies



Fixed effects model: heterogeneity NS

Source: Harland JI, Mc Keown NM and Garton LE, unpublished

WG and weight gain - Cohort studies

- Mean difference in weight gain -0.568kg (95%Cl: -0.43 to -0.71kg) (*P*<0.0001) over a period of 7.9yrs in 76912subjects
- Average intake of WG in highest groups ca 2.2 servings

Source: Harland JI, Mc Keown NM and Garton LE, unpublished

Other epidemiological studies

- The Vyronas Study, Athens
  - X sectional Health & Nutrition survey
  - 2004-5 survey in 2008, 12-17y olds where consumption of breakfast cereals associated with ↓BMI in boys (P=0.08) and girls (P=0.019)
  - pre-sweetened breakfast cereals associated ↓ BMI both boys & Girls (P<0.001)
  - consumption of breakfast cereals associated with 33% ↓ obesity (adjusted A, G, PA)

- Note breakfast cereals and bread usually predominant sources of WG in diet

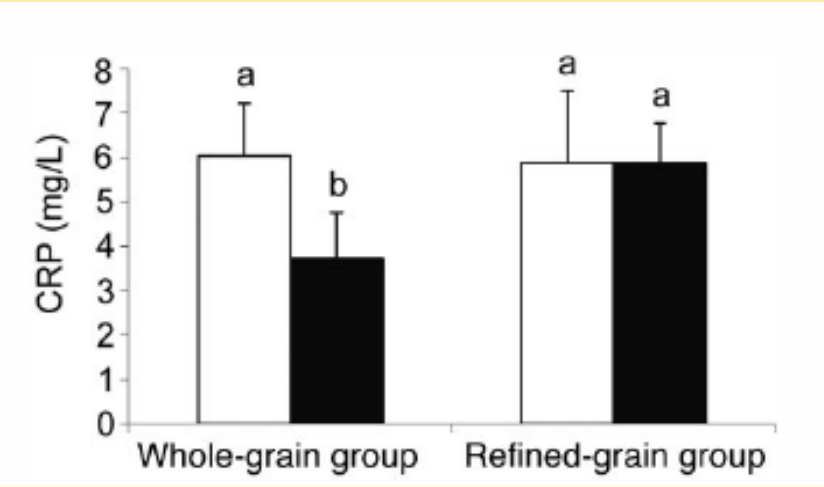
Source: Kosti RI, *et al. Public Health Nutr* 2008; **11**: 1015-21.

Epidemiological studies

- Only indicate associations
- Impossible to correct for all confounding factors
- Those with higher WG intake tend to have a healthier lifestyle - lower sat fat intake, higher fibre, fruit and veg, more physically active....

Clinical studies

- RCT: 25 subjects with metabolic syndrome/treatment, hypocaloric diet +/- WG for 12wks
  - Weight loss similar
  - Abdominal fat loss ↑ with WG: 2.2 v 0.9%
  - LDL-C or Total-C: no significant difference
  - Insulin tolerance improved
  - Inflammatory status/CVD risk improved (P<0.01)



Source: Katcher HI, *et al. Am J Clin Nutr* 2008; **87**: 79-90.

Potential mechanisms

- Satiety and Satiation
- Insulin sensitivity
- Dietary fibre
- Antioxidant effect
- Marker of a healthier lifestyle
- Other mechanisms - WG prebiotic, ↑ probiotic bacteria (Costabile 2008)

Source: Holt, S.H. and J.B. Miller, *Eur J Clin Nutr*, 1994. 48(7): 496-502.
Saltzman, E. et al, *J Am Coll Nutr*, 2001. 20(1): p. 50-7.
Van Dijk, G. and T.E. Thiele, *Neuropeptides*, 1999. 33: p. 406 - 414.
Pereira, M.A., et al. *Am J Clin Nutr*, 2002. 75(5): p. 848-55.
Lutsey PL, et al. *Br J Nutr* 2007:1-9.
Harland JI and Garton L, unpublished,
Costabile A, *et al. Br J Nutr* 2008; **99**: 110-20.

Wholegrains and Health

- An association between wholegrain consumption and a number or chronic diseases
  - Heart disease
  - Type 2 Diabetes
  - Cancer

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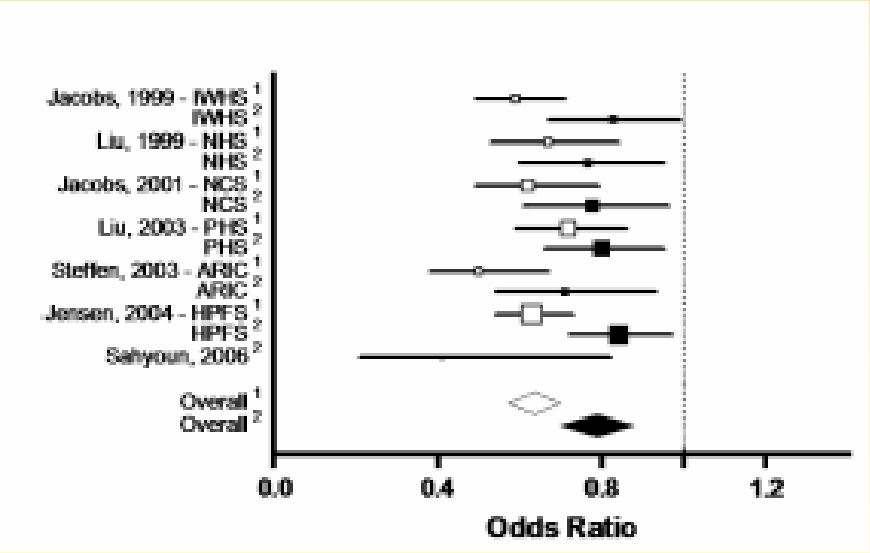
Heart Health

- Number of reviews of evidence that have resulted in health claims permitted for whole grain and heart health (USA, UK, Sweden)
- Meta analysis (Mellen 2007); 7 cohort studies
  OR =0.79 (2.5 v 0.2 WG servs) - 21% disease risk reduction



Source: Mellen PB, Walsh TF, Herrington DM. *Nutr Metab Cardiovasc Dis* 2007.

Type 2 Diabetes

- Systematic review and meta analysis; de Munter 2007
  6 cohort studies and 286,000 participants

- RR =0.79
  21% disease risk reduction

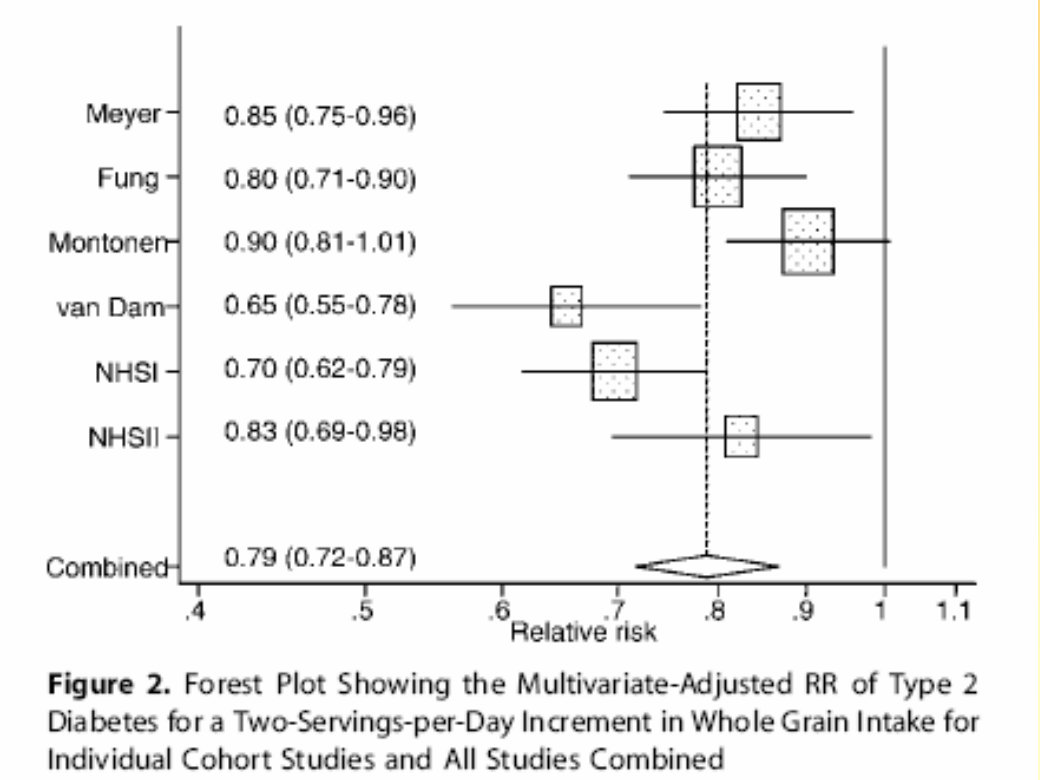


Figure 2. Forest Plot Showing the Multivariate-Adjusted RR of Type 2 Diabetes for a Two-Servings-per-Day Increment in Whole Grain Intake for Individual Cohort Studies and All Studies Combined

Source: de Munter JS, Hu FB, Spiegelman D, *et al. PLoS Med* 2007; **4**: e261.

Dietary Recommendations

- Dietary Guidelines for Americans 2005 recommend
  - 3 or more ounce-equivalents of whole-grain products per day, with the rest of the recommended grains coming from enriched or whole-grain products

This translates into at least 3 servings (16g each) of WG per day

- WHO 2003 Promoting healthy behaviours to encourage, motivate and enable individuals to lose weight by:

- eating more fruit and vegetables, as well as nuts and whole grains

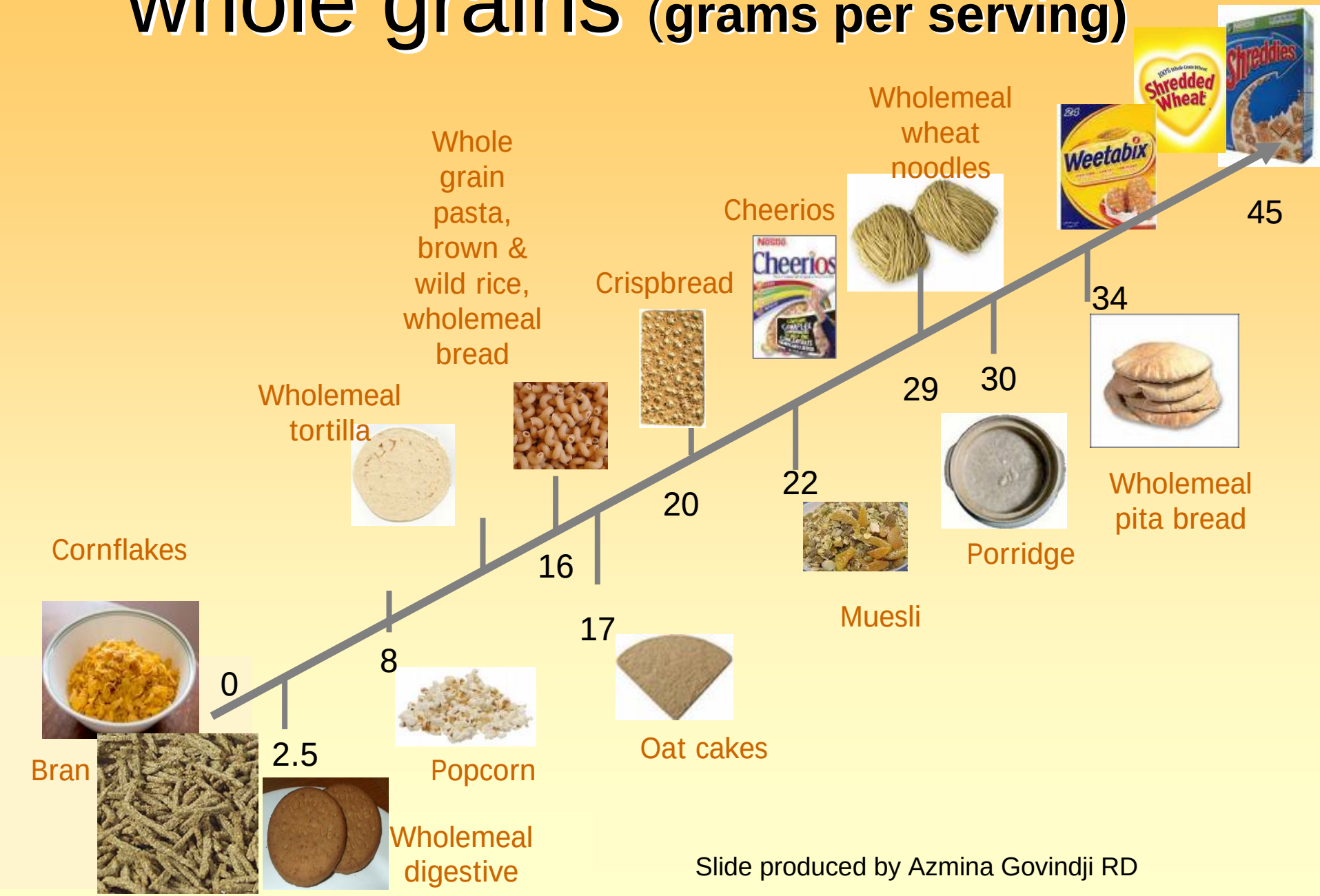
Dietary Recommendations

- In the UK we have no quantitative WG recommendations
  - eat plenty of bread, rice, potatoes, pasta and other starchy foods choose whole-grain varieties whenever you can'
    (FSA's Guidelines for a Healthy Diet)

- In Denmark the recommendation is for 75g or more of whole grains daily
  or 40-60g for children and for smaller women

- Singapore currently only has recommendations for children
  - 15-30g per day (1-2 year olds)
  - $\geq$ 30 g per day (13-18 year olds)

whole grains **(grams per serving)**



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Conclusions

- Higher WG consumption associated with lower BMI
- Higher WG consumption associated with lower central adiposity
- Higher WG consumption associated with lower weight gain over time
- Higher WG consumption associated with lower risk of obesity combined OR/RR =0.83
- Higher WG consumption, lower fat/sats intake and better micronutrient status, healthier lifestyle

* Easy to include more WG in the diet, through choice of breakfast cereals & bread

Acknowledgements

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- Thank you for your attention!