Published in final edited form as:
Eur J Clin Nutr. 2009 March ; 63(3): 303–311. doi:10.1038/sj.ejcn.1602954.

Consumption of red or processed meat does not predict risk factors for coronary heart disease; results from a cohort of British adults in 1989 and 1999

Jessie J.M.F. Wagemakers[1], **Celia J. Prynne**[1], **Alison M. Stephen**[1], and **Michael E.J. Wadsworth**[2]

[1]MRC Human Nutrition Research, Elsie Widdowson Laboratory, Fulbourn Road, Cambridge CB1 9NL, UK

[2]MRC National Survey of Health and Development, University College and Royal Free Medical School, 1-19 Torrington Place, London WC1E 6BT, UK

Abstract

Objectives—To investigate whether a high consumption of red or processed meat is associated with increased risk of coronary heart disease.

Subjects/Methods—The subjects were 517 men and 635 women who were members of the Medical Research Council National Survey of Health and Development, 1946 birth cohort. Assessment of diet was carried out at two time-points 1989 and 1999 with outcome measures collected in 1999. Food intake data were recorded in 5 -day diaries. Meat consumption was estimated by adding individual meat portions to the meat fractions of composite dishes.

Results—There was no significant association between red or processed meat consumption in 1989 and 1999 and serum cholesterol concentrations and blood pressure measured in 1999. The combined intake of red and processed meat in 1999 had a significant positive association with blood pressure in men only. Red and processed meat intakes in 1989 separately and combined had a significant positive association with waist circumference in 1999: a 10g increase in red meat consumption accounted for a 0.3cm increase in waist circumference; p=0.04 (men), 0.05 (women).

Conclusions—Consumption of red or processed meat assessed separately was not related to the major risk factors for CHD but did contribute to increased waist circumference that has also been identified as a risk factor.

Keywords

Diet; Coronary heart disease; Meat; Cholesterol; Blood pressure; Waist circumference

Introduction

While there has been a steady decline since 1980, death rates from coronary heart disease (CHD) in the United Kingdom (UK) are still among the highest in Western Europe. The latest data available for the UK reported 105,842 deaths, men and women combined, in 2004 (British Heart Foundation 2007). At least 75% of new cases of CHD can be explained by

Correspondence to: Dr CJ Prynne MRC Human Nutrition Research, Elsie Widdowson Laboratory, Fulbourn Road, Cambridge CB1 9NL, United Kingdom. Tel: 01223 426356 Fax: 01223 437515 celia.greenberg@mrc-hnr.cam.ac.uk.
Contributors: CP and JW were responsible for analysis of the data and preparation of the manuscript. AS conceptualised the study and provided critical revision of the paper. MW was responsible for the cohort study design and data collection and approved the project and also provided critical revision of the paper.

Europe PMC Funders Author Manuscripts

inappropriate diet, low level of physical activity and smoking, as primarily expressed through unfavorable serum lipid concentrations, high body mass index (BMI) and raised blood pressure (Beaglehole and Magnus 2002). Numerous studies have demonstrated that an increase in saturated fat intake is associated with elevated blood total cholesterol levels (Clarke *et al.* 1997; Tang *et al.* 1998; Safeer and Ugalat 2002; German and Dillard 2004; Li *et al.* 2005), while a high intake of sodium is associated with hypertension (Law *et al.* 1991; Appel *et al.* 1997; Krauss *et al.* 2000).

Meat and meat products are important sources of saturated fat and sodium in the UK contributing 23% and 26% to the mean intake overall respectively (Henderson *et al.* 2003). Red meat consumption is a characteristic of the typical northern European diet, which also contains large quantities of dairy products, highly refined carbohydrates, hydrogenated fats, and small quantities of vegetables and fruit (Kushi *et al.* 1995). This dietary pattern has been shown to be related to an increased risk of CHD (Kushi *et al.* 1995; Appel *et al.* 1997; Hu *et al.* 1999; Hu *et al.* 2000; Miura *et al.* 2004;). However, meat is an important source of high quality protein and micronutrients: B-vitamins, zinc, haem-iron and vitamins A and D (Linseisen *et al.* 2002; Cosgrove *et al.* 2005).

Meat is a diverse food group and the quantity of macro- and micronutrients varies for different types of meat. For example, fat content can range between 4% (lean poultry) and 40% (fatty red meat) (Linseisen *et al.* 2002). Furthermore, meat is often a part of mixed dishes containing vegetables and/or cereals so it is important to disaggregate meat from composite foods to prevent incorrect estimates of meat consumption (Cosgrove *et al.* 2005).

It has been reported that the consumption of both red and processed meat are associated with risk factors for CHD; in particular, raised total cholesterol and low- density-lipoprotein (LDL) cholesterol concentrations, greater body mass index (BMI) and raised blood pressure (Slattery *et al.* 1991; Miura *et al.* 2004; Steffen *et al.* 2005). The aim of this study is to examine the relationship between consumption of red and processed meat, after disaggregation of composite dishes, with risk factors for CHD using the data from the UK Medical Research Council (MRC) National Survey of Health and Development (NSHD) 1946 Birth Cohort. This is a longitudinal survey, in which dietary and health data have been collected at several time points during adult life. Meat consumption was assessed in 1989 and 1999 and related to risk factors assessed in 1999. Thus it was possible to investigate whether meat consumption could predict CHD risk ten years later.

Subjects and methods

Study population and study design

The study population comprised 1152 men and women who were members of the MRC National Survey of Health and Development (NSHD). This cohort is a social-class-stratified random sample of 5362 singleton legitimate births in England, Scotland and Wales during the first week of March 1946. When survey members were aged 43 and 53, in 1989 and 1999 respectively, a research nurse visited and interviewed them in their own homes. Subjects were asked to record their diet in 5-day diaries. Blood pressure and anthropometric data were measured and, in 1999 only, non-fasting venous blood samples were drawn. The present analyses were of data collected from subjects who completed at least three days of the food diary in 1989 and 1999 and for whom serum cholesterol levels, blood pressure, BMI, and waist circumference were measured in 1999. Members of the cohort who were visited in 1989 and 1999 were representative of the native born population of a similar age (Wadsworth *et al.* 1992; Wadsworth *et al.* 2003). However, due to the selection requirements for this study, the number of subjects was less than all those contacted in 1999 and there was a bias towards non-manual socio-economic classes.

Dietary assessment

All food and drink consumed was recorded using household measures with portion sizes estimated according to detailed guidance notes and photographs provided in the diary. The diaries were coded using the in-house program DIDO (Diet In Data Out). Weights of meat, meat dishes, and meat products were calculated from the coded food diary using the in-house suite of programs based on McCance and Widdowson's *The Composition of Foods*, fourth and sixth edition (Paul A.A. 1978; Food Standards Agency 2002). In total, 140 food codes that contained meat were recorded in 1989 and 210 in 1999. Of these, 44% in 1989 and 56% in 1999 were composite dishes containing a variable percentage of meat. The meat content of each of these mixed dishes was calculated and added to individual meat portions to arrive at a more precise measure of total meat intake (Prynne *et al.* 2007).

The analyses were based on the consumption of the two meat categories:

1. Red meat: beef, lamb, pork, veal and mutton.
2. Processed meat: ham, bacon, sausages, processed meat cuts and processed minced meat.

Since the intake of offal and game was very low, they were omitted from all the analysis.

Measures

Information about lifestyle, demographic factors and socio-economic status was collected at home visits by research nurses trained by study staff in 1989 and 1999.

Socio-economic status and region were defined at age 43. Socio-economic status was based on occupation and categorized into non-manual (managerial, professional, skilled professional ancillaries and service providers) and manual (skilled, non-skilled and agricultural workers). Three regions of residence were defined: 1) Scotland, North, North West and Yorkshire 2) Midlands, North Midlands, Eastern and Wales 3) South West, Southern, London and South East. Alcohol consumption was calculated from the dietary records in grams/day and converted into units: 1 unit = 8 grams. Alcohol consumption was then categorized in 1999 as none, 1-2 units/ day, and >2 units/ day. Smoking status was assessed in 1999 by asking whether the subjects smoked currently, in the past or never.

The research nurses, who followed standardized procedures, measured anthropometric data in the form of weight, height and waist circumference in 1989 and 1999. BMI (kg/m^2) was calculated from these measurements as body weight divided by the square of standing height. Systolic and diastolic blood pressures were measured twice and means of duplicate measurements were used in all analyses. In 1999 only, non-fasting venous blood samples were analysed for total serum cholesterol concentration and HDL cholesterol with a Bayer DAX-72 analyser. Total cholesterol concentration was determined by enzymatic CHOD-PAP. Phosphotungstic Mg^{2+} was used to establish HDL cholesterol. LDL cholesterol was calculated by Friedewald formula: LDL-C = Total cholesterol − HDL cholesterol − LDL cholesterol − (triglyceriden/2.2) (in mg/dl)(Gazi *et al.* 2006).

Statistical analysis

Descriptive data were presented as means and standard deviation (SD) or median and interquartile range (IQR) for continuous variables and as percentages for categorical variables for men and women separately. Variations in meat consumption between men and women, between years, between regions and occupational social classes were compared using one-way analysis of variance (ANOVA).

Processed meat and red meat were divided into thirds, based on the mean intake per day in 1989 and 1999 of these meat categories. Differences in health outcomes were compared for the different subgroups (low, middle, high consumption) within the meat categories by using one-way analysis of variance (ANOVA) with *post hoc* Bonferroni tests.

Multiple linear regression analysis was carried out to investigate associations between meat consumption in 1989 and 1999, as a continuous variable, and health outcomes in 1999. Regression analysis was carried out to determine associations with serum cholesterol, blood pressure, BMI and waist circumference after adjustment for potential confounders; total energy intake, alcohol consumption, smoking, region and socio-economic status.

Statistical analyses were carried out by using the statistical software program SPSS version 10.1 for Windows.

Results

Demographic and physical characteristics are shown separately for men and women in table 1. 51.5% of the subjects who had been assessed in 1989 provided blood samples in 1999 and were included in this analysis. Body weight increased in the subjects in this study by more than 5 kg for both men and women between 1989 and 1999. Over 80% of the study population did not smoke in 1999 although 53% of the men and 36% of the women had smoked in the past. Less than a quarter of the sample consumed no alcohol in the assessment period in 1999 but 42% of the men and 15% of the women exceeded the recommendation of the British Heart Foundation, as they drank more than 2 units per day.

Table 2 shows the arithmetic mean, median and interquartile range of intakes of red meat and processed meat. Men consumed significantly more red meat and processed meat than women at both ages 43 and 53 years. The intake of red and processed meat was significantly lower in 1999 compared to 1989 in both men and women. There were no significant differences in meat consumption between regions for men or women in 1989 and 1999. Red meat consumption did not differ between social classes in either year but consumption of processed meat was significantly higher in the manual social class in both men (35g/day, manual; 28g/day, non manual; p=0.003) and women (23g/day, manual; 19g/day, non manual; p=0.02) in 1999 only.

Table 3 shows the total, LDL and HDL cholesterol concentrations and blood pressures of the 1152 subjects in 1999. Women had significantly higher mean HDL cholesterol concentration (p=0.002) and lower mean diastolic blood pressure (p<0.005).

Tables 4 and 5 show the means of cardiovascular risk factors measured in 1999 across thirds of red meat and processed meat consumed in 1989. There were no significant differences between thirds of meat consumption by men or women. Tables 6 and 7 show the means of cardiovascular risk factors measured in 1999 across thirds of red meat and processed meat consumed in 1999. Waist circumference of men was significantly greater in the highest third of red meat consumption. In women, LDL cholesterol, BMI and waist circumference were increased in the high consumers but not significantly. The highest consumers of processed meat, both men and women, had significantly increased waist circumference and BMI, the latter borderline in the men.

Table 8 shows the means of blood pressure, waist circumference and BMI across thirds of combined red and processed meat intake. The highest male consumers of these meats in both 1989 and 1999 had significantly greater BMI and waist circumference. In men only, blood pressure was also significantly higher in those with the greatest consumption of red and processed meats in 1999. Total, LDL and HDL cholesterol concentrations did not differ

significantly between thirds of intakes of combined red and processed meat in 1989 and 1999 (results not show).

Regression analyses confirmed that there were no significant associations between weights of red or processed meat consumed in 1989 or 1999 and serum cholesterol concentration and blood pressure measured in 1999. Table 9 shows the significant positive associations that were found between red and processed meat consumption and combined in 1989 and 1999 and BMI and waist circumference in 1999 in both men and women. Results indicated that a 10 gram increase in red meat consumption in 1989 was associated with a 0.3 cm increase in waist circumference of men (p=0.035) and women (p=0.048) in 1999. A similar association was found for consumption of processed meat. Red and processed meat consumed in 1999 was significantly associated with increased BMI in women only. Table 10 shows the associations between combined red and processed meat consumption in 1989 and 1999 and blood pressure in 1999. A significant positive association was found for 1999 meat intake in men only.

Discussion

This paper examined consumption of red meat and processed meat in 1989 and 1999 in a British birth cohort in relation to CHD risk factors in 1999. We have previously reported that high consumers of processed meat had an unhealthier diet with regard to the key nutrients (Prynne *et al.* 2007). The results of this study suggest that red or processed meat consumption measured 10 years earlier or synchronously do not predict an increased risk of CVD as indicated by cholesterol concentration or blood pressure. However there were significant positive associations between meat consumption and BMI and waist circumference.

This study used a more accurate estimate of total meat consumption by adding only the meat fraction of mixed or composite dishes to individual meat portions (Prynne *et al.* 2007). Other strengths of our study were the large sample size, the availability of data across all regions in the UK and the longitudinal study design, which gave us the possibility to predict health in the future based on dietary intakes in the past.

Our study had some limitations. Consumption of meat was self-reported; thus reporting bias might have affected our estimates of the effect. Furthermore, of the subjects from whom we had dietary data in 1989 not all provided physiological data in 1999 and were therefore not included in the study. Of those that were included there were a majority who belonged to non-manual socio-economic classes who may have been more health-aware. Furthermore, when risk factors were measured in 1999 the subjects were 10 years older than when the dietary data were collected in 1989. Changes in cholesterol levels, blood pressure and weight could be due to the ageing population *per se* or there may have been other dietary factors that changed with age.

This study did not find any significant difference in total, HDL or LDL cholesterol across the categories of red meat and processed meat consumed 10 years earlier or synchronously with the cholesterol measurements. This is in line with several dietary interventions and cross-sectional studies in which no rise in blood cholesterol and LDL cholesterol was found after consumption of red meat (Li *et al.* 2005). Nicklas *et al.* also found no differences in total, LDL and HDL cholesterol across quartiles of meat consumption by a group of 504 young adults aged 19-28 years (Nicklas *et al.* 1995). In an intervention study involving 38 hypercholesterolaemic men consumption of chicken or beef caused a decrease in LDL and total cholesterol and an increase in HDL cholesterol when saturated fat intake was maintained at the same level (Scott *et al.* 1994) and hypercholesterolaemic men fed a lipid

lowering diet had reduced plasma total and LDL cholesterol regardless of whether they ate chicken or beef (Beauchesne-Rondeau *et al.* 2003). However, in a cross sectional study of young adults Slattery *et al.* found lower total and LDL cholesterol concentrations in those who ate red meat and poultry less than once a week compared with young adults who consumed meat more frequently (Slattery *et al.* 1991). These results would seem to imply that meat *per se* does not have an effect on plasma cholesterol concentrations but it is the dietary pattern associated with the consumption of particular types of meat. The diet associated with the consumption of processed meat in the NSHD had a higher fat content but the fat was not necessarily meat fat (Prynne *et al.* 2007). Not all saturated fatty acids are equally hypercholesterolaemic; beef fat contains relatively more stearic acid compared to milk fat that contains more myristic and palmitic fatty acids; the latter having greater cholesterol–raising potential (Ulbricht and Southgate 1991).

Previous observational studies reported that dietary patterns characterized by a high intake of red and processed meat were positively associated with systolic and diastolic blood pressure (Ascherio *et al.* 1996; Miura *et al.* 2004; Steffen *et al.* 2005), and vegetarians were reported to have lower blood pressure than the general population (Sacks and Kass 1988). Longitudinal data from the DASH study suggest that a diet low in red meat results in significantly reduced systolic and diastolic blood pressure (Appel *et al.* 1997). In the NSHD, meat consumption did not predict elevated blood pressure 10 years later but there was a significant rise in systolic and diastolic blood pressure in 1999 associated with a higher intake of red and processed meat combined in men but not women at the same time point. We have previously reported that high consumers of processed meat in the NSHD cohort had significantly higher sodium intakes (Prynne *et al.* 2007). It is well established that salt intake is associated with increased blood pressure (Law *et al.* 1991; Khaw *et al.* 2004) so a relationship between processed meat and blood pressure, if detected, could probably be due to the salt that is added during processing rather than the meat.

Many cross-sectional studies have investigated the relationship between diet patterns and BMI or waist circumference (Togo *et al.* 2001; Newby *et al.* 2003; Rosell *et al.* 2006). There was limited evidence suggesting that a diet low in meat was associated with a lower BMI (Togo *et al.* 2001). Furthermore, healthy elderly of the US Framingham Heart Study and the European SENECA study who were in the meat and fat cluster tended to have highest waist circumference and BMI. (Haveman-Nies *et al.* 2001). Our results showed a positive association between intake of red or processed meat and waist circumference measured 10 years later and if red and processed meats were combined there was also a positive association with BMI. Both men and women in the NSHD had reduced total red and processed meat consumption by 1999 compared to 1989 but this was still associated with increased waist circumference and, in women, BMI also.

In conclusion, the results presented did not show that consumption of red or processed meat by the NSHD subjects related to traditional risk factors for CHD. Any relationship between meat consumption and to CHD risk reported from other studies might be from the type of diet of which these foods form a part; i.e. a diet containing high levels of saturated fat and sodium and, possibly, a low intake of fruit and vegetables. This is recognised in the COMA report which recommended that the intake of red meat should not be reduced but eaten trimmed of fat (Department of Health 1994). It did recommend that the intake of meat products be halved in order to reduce fat and sodium intakes and that vegetable and fruit consumption be increased. The members of the 1946 birth cohort in 1999 would appear to have heeded that advice as their total fat intake was reduced and they consumed less processed meat but increased fruit and vegetables compared to 1989 (Prynne *et al.* 2005; Prynne *et al.* 2007). These subjects were 53 years of age in 1999, an age when health and mortality becomes more immediately pertinent, so our findings may not be able to be

extrapolated to the general population of the UK. More prospective studies of wider population groups are needed with careful and accurate estimations of meat consumption to answer these questions conclusively.

Acknowledgments

Sponsorship: This work was supported by the UK Medical Research Council.

JW acknowledges the support she received from the Netherlands Heart Foundation for her internship in Cambridge.

References

Appel LJ, Moore TJ, Obarzanek E, Vollmer WM, Svetkey LP, Sacks FM, et al. A clinical trial of the effects of dietary patterns on blood pressure. DASH Collaborative Research Group. N Engl J Med. 1997; 336:1117–1124. [PubMed: 9099655]

Ascherio A, Hennekens C, Willett WC, Sacks F, Rosner B, Manson J, et al. Prospective study of nutritional factors, blood pressure, and hypertension among US women. Hypertension. 1996; 27:1065–1072. [PubMed: 8621198]

Beaglehole R, Magnus P. The search for new risk factors for coronary heart disease: occupational therapy for epidemiologists? Int J Epidemiol. 2002; 31:1117–22. author reply 1134-1135. [PubMed: 12540704]

Beauchesne-Rondeau E, Gascon A, Bergeron J, Jacques H. Plasma lipids and lipoproteins in hypercholesterolemic men fed a lipid-lowering diet containing lean beef, lean fish, or poultry. Am J Clin Nutr. 2003; 77:587–593. [PubMed: 12600847]

British Heart Foundation. 2007www.heartstats.org

Clarke R, Frost C, Collins R, Appleby P, Peto R. Dietary lipids and blood cholesterol: quantitative meta-analysis of metabolic ward studies. Brit Med J. 1997; 314:112–117. [PubMed: 9006469]

Cosgrove M, Flynn A, Kiely M. Consumption of red meat, white meat and processed meat in Irish adults in relation to dietary quality. Brit J Nutr. 2005; 93:933–942. [PubMed: 16022764]

Cosgrove M, Flynn A, Kiely M. Impact of disaggregation of composite foods on estimates of intakes of meat and meat products in Irish adults. Public Health Nutr. 2005; 8:327–337. [PubMed: 15918931]

Department of Health. Nutritional Aspects of Cardiovascular Disease. Report of the Cardiovascular Review Group Committee on Medical Aspects of Food Policy. HMSO; London: 1994.

Food Standards Agency. McCance and Widdowson's The Composition of Foods. Sixth summary edition. Royal Society of Chemistry; Cambridge: 2002.

Gazi I, Tsimihodimos V, Filippatos TD, Saougos VG, Bairaktari ET, Tselepis AD, et al. LDL cholesterol estimation in patients with the metabolic syndrome. Lipids Health Dis. 2006; 5:8–15. [PubMed: 16600020]

German JB, Dillard CJ. Saturated fats: what dietary intake? Am J Clin Nutr. 2004; 80:550–559. [PubMed: 15321792]

Haveman-Nies A, Tucker KL, de Groot LC, Wilson PW, van Staveren WA. Evaluation of dietary quality in relationship to nutritional and lifestyle factors in elderly people of the US Framingham Heart Study and the European SENECA study. Europ J Clin Nutr. 2001; 55:870–880.

Henderson, L.; Gregory, J.; Irving, K. Energy, protein, carbohydrate, fat and alcohol intake. Vol. Volume 2. The Stationery Office; London: 2003. The National Diet and Nutrition Survey: adults aged 19 to 64 years.

Hu FB, Rimm EB, Stampfer MJ, Ascherio A, Spiegelman D, Willett WC. Prospective study of major dietary patterns and risk of coronary heart disease in men. Am J Clin Nutr. 2000; 72:912–921. [PubMed: 11010931]

Hu FB, Stampfer MJ, Manson JE, Ascherio A, Colditz GA, Speizer FE, et al. Dietary saturated fats and their food sources in relation to the risk of coronary heart disease in women. Am J Clin Nutr. 1999; 70:1001–1008. [PubMed: 10584044]

Khaw KT, Bingham S, Welch A, Luben R, O'Brien E, Wareham N, et al. Blood pressure and urinary sodium in men and women: the Norfolk Cohort of the European Prospective Investigation into Cancer (EPIC-Norfolk). Am J Clin Nutr. 2004; 80:1397–1403. [PubMed: 15531692]

Krauss RM, Eckel RH, Howard B, Appel LJ, Daniels SR, Deckelbaum RJ, et al. AHA Dietary Guidelines: revision 2000: A statement for healthcare professionals from the Nutrition Committee of the American Heart Association. Stroke. 2000; 31:2751–2766. [PubMed: 11062305]

Kushi LH, Lenart EB, Willett WC. Health implications of Mediterranean diets in light of contemporary knowledge. 2. Meat, wine, fats, and oils. Am J Clin Nutr. 1995; 61:1416S–1427S. [PubMed: 7754997]

Law MR, Frost CD, Wald NJ. Dietary salt and blood pressure. J Hypertens Suppl. 1991; 9:S37–41. discussion S47-9. [PubMed: 1818998]

Li D, Siriamornpun S, Wahlqvist ML, Mann NJ, Sinclair AJ. Lean meat and heart health. Asia Pac J Clin Nutr. 2005; 14:113–119. [PubMed: 15927927]

Linseisen J, Kesse E, Slimani N, Bueno-De-Mesquita HB, Ocke MC, Skeie G, et al. Meat consumption in the European Prospective Investigation into Cancer and Nutrition (EPIC) cohorts: results from 24-hour dietary recalls. Public Health Nutr. 2002; 5:1243–1258. [PubMed: 12639230]

Miura K, Greenland P, Stamler J, Liu K, Daviglus ML, Nakagawa H. Relation of vegetable, fruit, and meat intake to 7-year blood pressure change in middle-aged men: the Chicago Western Electric Study. Am J Epidemiol. 2004; 591:572–580. [PubMed: 15003961]

Newby PK, Muller D, Hallfrisch J, Qiao N, Andres R, Tucker KL. Dietary patterns and changes in body mass index and waist circumference in adults. Am J Clin Nutr. 2003; 77:1417–1425. [PubMed: 12791618]

Nicklas TA, Farris RP, Myers L, Berenson GS. Impact of meat consumption on nutritional quality and cardiovascular risk factors in young adults: the Bogalusa Heart Study. J Am Diet Assoc. 1995; 95:887–892. [PubMed: 7636079]

Paul, AA.; Southgate, DAT. McCance and Widdowson's The composition of foods. 4th edition. HMSO; London: 1978.

Prynne CJ, Paul AA, Mishra GD, Greenberg DC, Wadsworth MEJ. Changes in intake of key nutrients over 17 years during adult life of a British birth cohort. Brit J Nutr. 2005; 94:368–376. [PubMed: 16176607]

Prynne, CJ.; Wagemakers, J.; Stephen, A.; Wadsworth, ME. Meat consumption after disaggregation of meat dishes of a cohort of British adults in 1989 and 1999 and relation to diet quality. 2007. submitted

Rosell M, Appleby P, Spencer E, Key T. Weight gain over 5 years in 21 966 meat-eating, fish-eating, vegetarian, and vegan men and women in EPIC-Oxford. Int J Obes (Lond). 2006; 30:1389–96. [PubMed: 16534521]

Sacks FM, Kass EH. Low blood pressure in vegetarians: effects of specific foods and nutrients. Am J Clin Nutr. 1988; 48:795–800. [PubMed: 3414588]

Safeer RS, Ugalat PS. Cholesterol treatment guidelines update. Am Fam Physician. 2002; 65:871–880. [PubMed: 11898959]

Scott LW, Dunn JK, Pownall HJ, Brauchi DJ, McMann MC, Herd JA, et al. Effects of beef and chicken consumption on plasma lipid levels in hypercholesterolemic men. Arch Intern Med. 1994; 154:1261–1267. [PubMed: 8203993]

Slattery ML, Jacobs DR Jr. Hilner JE, Caan BJ, Van Horn L, Bragg C, et al. Meat consumption and its associations with other diet and health factors in young adults: the CARDIA study. Am J Clin Nutr. 1991; 54:930–935. [PubMed: 1951168]

Steffen LM, Kroenke CH, Yu X, Pereira MA, Slattery ML, Van Horn L, et al. Associations of plant food, dairy product, and meat intakes with 15-y incidence of elevated blood pressure in young black and white adults: the Coronary Artery Risk Development in Young Adults (CARDIA) Study. Am J Clin Nutr. 2005; 82:1169–1177. [PubMed: 16332648]

Tang JL, Armitage JM, Lancaster T, Silagy CA, Fowler GH, Neil HA. Systematic review of dietary intervention trials to lower blood total cholesterol in free-living subjects. Brit Med J. 1998; 316:1213–1220. [PubMed: 9552999]

Togo P, Osler M, Sorensen TI, Heitmann BL. Food intake patterns and body mass index in observational studies. Int J Obes Relat Metab Disord. 2001; 25:1741–1751. [PubMed: 11781753]

Ulbricht T, Southgate DAT. Coronary heart disease:seven dietary factors. Lancet. 1991; 338:985–992. [PubMed: 1681350]

Wadsworth ME, Butterworth SL, Hardy RJ, Kuh DJ, Richards M, Langenberg C, et al. The life course prospective design: an example of benefits and problems associated with study longevity. Soc Sci Med. 2003; 57:2193–2205. [PubMed: 14512249]

Wadsworth ME, Mann SL, Rodgers B, Kuh DJ, Hilder WS, Yusuf EJ. Loss and representativeness in a 43 year follow up of a national birth cohort. J Epidemiol Community Health. 1992; 46:300–304. [PubMed: 1645091]

Europe PMC Funders Author Manuscripts

Europe PMC Funders Author Manuscripts

Table 1

Characteristics of the subjects

Characteristics	Men (n=517)	Women (n=635)
Weight (1989), kg	76.3 (10.8)	63.8 (10.7)
Weight (1999), kg	81.4 (12.1)	69.6 (12.7)
Smoking (1999), %		
Current	16	17
Ever	52	36
Never	47	64
Alcohol consumers (1999), %		
No alcohol consumption	19	27
1-2 units/ day	39	58
> 2 units/ day	42	15
Socio-economic class (1989), %		
Non manual	64	70
Manual	33	23
Not recorded	3	7
Region (1989), %		
Scotland, North, N.West, Yorkshire	34	29
N. Midlands, Eastern, Wales	23	27
London, S. East, S.West, Southern	43	44

Data are mean (sd) or percentages.

Europe PMC Funders Author Manuscripts

Eur J Clin Nutr. Author manuscript; available in PMC 2009 October 26.

Table 2

Means, medians and IQR of intakes (g/day) of red meat and processed meat of men and women in 1989, aged 43 years, and 1999, aged 53 years

		Non-meat-consumers (non –consumers of red or processed meat only)	Red meat			Processed meat		
			Mean	Median	IQR	Mean	Median	IQR
Men n =517	1989, age 43 years	1.5 (2.1)	47.4 *	42.2	18.0, 68.0	42.7 *	35.9	19.4, 61.4
	1999, age 53 years	2.1 (4.4)	40.8 *§	36.0	17.0,57.7	30.6 *¥	25.7	10.0, 44.4
Women n =635	1989, age 43 years	2.5 (4.1)	35.7	29.5	13.5, 53.8	27.2	23.2	11.2, 40.3
	1999, age 53 years	3.3 (8.5)	29.8 ¥	24.9	5.8, 47.5	19.6 ¥	15.2	6.2, 28.6

IQR = Interquartile range

* Values between men and women in corresponding year were significantly different: $P<0.001$.

§ Values between 1989 and 1999 for men and women separately were significantly different: $P=0.001$

¥ $P<0.001$

Europe PMC Funders Author Manuscripts

Table 3

Means (SD) of blood and body size measurements of men and women in 1999, aged 53 years

	Men (n=517)	Women (n=635)	*p*
Total cholesterol, mmol/L	5.91 (1.02)	6.13 (1.15)	NS
LDL cholesterol, mmol/L	3.51 (0.98)	3.48 (1.03)	<0.001
HDL cholesterol, mmol/L	1.51 (0.58)	1.88 (0.50)	<0.001
Systolic bp, mmHg	138.5 (19.0)	133.1 (19.2)	<0.001
Diastolic bp, mmHg	86.4 (11.3)	81.9 (10.7)	<0.001
BMI, kg/m^2	26.5 (3.5)	26.3 (4.7)	NS
Waist circumference, cm	95.5 (10.0)	83.2 (11.2)	<0.001

bp = blood pressure

Europe PMC Funders Author Manuscripts

Table 4

Means (SD) of cardiovascular risk factors in 1999 by thirds of red meat intake in 1989 in men and women

	Men n=517				Women n=635			
Health outcomes 1999	**Thirds of red meat intake in 1989[1]**			**ANOVA**	**Thirds of red meat intake in 1989[2]**			**ANOVA**
Age 53 years	**Age 43 years**				**Age 43 years**			
	Low	**Middle**	**High**	***p***	**Low**	**Middle**	**High**	***p***
Total cholesterol,mmol/L	5.88 (0.98)	6.01 (1.03)	5.85 (1.06)	NS	6.15 (1.16)	6.15 (1.11)	6.09 (1.18)	NS
LDL cholesterol,mmol/L	3.49 (0.92)	3.60 (0.99)	3.43 (1.02)	NS	3.53 (1.06)	3.46 (0.97)	3.45 (1.07)	NS
HDL cholesterol,mmol/L	1.47 (0.43)	1.52 (0.64)	1.56 (0.66)	NS	1.86 (0.47)	1.91 (0.51)	1.87 (0.52)	NS
Systolic bp, mm Hg	137.7 (19.2)	137.8 (18.3)	139.9 (19.6)	NS	132.6 (18.4)	131.6 (20.1)	135.1 (19.0)	NS
Diastolic bp, mm Hg	85.5 (10.9)	86.0 (10.7)	87.6 (12.2)	NS	82 (10.8)	81 (10.3)	82.8 (11.04)	NS
BMI, kg/m^2	26.2 (3.3)	26.7 (3.5)	26.8 (3.7)	NS	26.4 (4.9)	26.4 (4.5)	26.8 (4.7)	NS
Waist circumference, cm	94.4 (9.6)	95.5 (9.4)	96.6 (10.9)	NS	82.0 (11.1)	83.4 (10.7)	84.3 (11.8)	NS

bp = blood pressure

[1] Thirds of red meat consumption; men: low: 0 – 29g/day, middle: 30 – 61g/day, high: 62 – 224g/day

[2] Thirds of red meat consumption; women: low: 0 – 18g/day, middle: 18 – 44g/day, high: 45 – 231g/day

Europe PMC Funders Author Manuscripts

Eur J Clin Nutr. Author manuscript; available in PMC 2009 October 26.

Table 5

Means (SD) of cardiovascular risk factors in 1999 by thirds of processed meat intake in 1989 in men and women

	Men n=517				Women n=635			
Health outcomes 1999	**Thirds of processed meat intake in 1989[1]**			**ANOVA**	**Thirds of processed meat intake in 1989[2]**			**ANOVA**
Age 53 years	**Age 43 years**				**Age 43 years**			
	Low	**Middle**	**High**		**Low**	**Middle**	**High**	
Total cholesterol, mmol/L	5.91 (0.98)	5.95 (1.06)	5.88 (1.05)	NS	6.16 (1.09)	6.14 (1.17)	6.08 (1.18)	NS
LDL cholesterol, mmol/L	3.51 (0.97)	3.51 (0.96)	3.52 (1.01)	NS	3.53 (1.0)	3.49 (1.04)	3.42 (1.06)	NS
HDL cholesterol, mmol/L	1.58 (0.64)	1.49 (0.44)	1.47 (0.63)	NS	1.87 (0.47)	1.88 (0.47)	1.88 (0.56)	NS
Systolic bp, mm Hg	138.3 (19.7)	138.6 (19.2)	138.7 (18.8)	NS	131.9 (18.3)	134.9 (18.5)	132.5 (20.6)	NS
Diastolic bp, mm Hg	85.9 (10.8)	86.5 (12.3)	86.7 (10.7)	NS	81.5 (10.5)	82.6 (10.4)	81.7 (11.2)	NS
BMI, kg/m^2	26.2 (3.4)	26.4 (3.6)	27.0 (3.5)	NS	26.3 (4.5)	21.5 (4.8)	26.7 (4.9)	NS
Waist circumference, cm	94.7 (10.1)	95.0 (9.8)	97.0 (10.0)	NS	82.4 (11.2)	83.2 (11.2)	83.9 (11.3)	NS

bp = blood pressure

[1] Thirds of processed meat consumption; men: low: 0 – 26g/day, middle: 27 – 52g/day, high: 53 – 233g/day

[2] Thirds of processed meat consumption; women: low: 0 – 15g/day, middle: 15 – 34g/day, high: 34 – 203g/day

Europe PMC Funders Author Manuscripts

Eur J Clin Nutr. Author manuscript; available in PMC 2009 October 26.

Table 6

Means (SD) of cardiovascular risk factors in 1999 by thirds of red meat intake in 1999 in men and women

	Men n=517				Women n=635			
Health outcomes 1999	**Thirds of red meat intake in 1999[1]**			**ANOVA**	**Thirds of red meat intake in 1999[2]**			**ANOVA**
Age 53 years	**Age 53 years**				**Age 53 years**			
	Low	**Middle**	**High**	***p***	**Low**	**Middle**	**High**	***p***
Total cholesterol, mmol/L	5.98 (0.95)	5.82 (1.16)	5.95 (0.99)	NS	6.12 (1.15)	6.02 (1.04)	6.25 (1.25)	NS
LDL cholesterol, mmol/L	3.61 (0.98)	3.40 (0.98)	3.52 (0.97)	NS	3.48 (1.03)	3.38 (0.92)	3.59 (1.14)	NS
HDL cholesterol, mmol/L	1.53 (0.66)	1.48 (0.39)	1.55 (0.65)	NS	1.9 (0.48)	1.88 (0.48)	1.85 (0.54)	NS
Systolic bp, mm Hg	137.6 (19.7)	138.4 (18.1)	140 (19.3)	NS	132.0 (19.1)	132.1 (17.4)	135.2 (20.8)	NS
Diastolic bp, mm Hg	86.0 (10.5)	85.5 (11.9)	87.5 (11.3)	NS	81.6 (10.7)	81.6 (9.9)	82.7 (11.5)	NS
BMI, kg/m^2	26.3 (3.1)	26.6 (3.7)	26.7 (3.7)	NS	25.9 (4.4)	26.7 (5.0)	26.9 (4.7)	0.06
Waist circumference, cm	93.7 (9.2)	96.7 (10.4)	96.1 (10.1)	0.013	81.7 (10.5)	83.7 (11.8)	84.0 (11.3)	0.07

bp = blood pressure

[1] Thirds of red meat consumption; men: low: 0 – 22g/day, middle: 23 – 50g/day, high: 50 – 281g/day

[2] Thirds of red meat consumption; women: low: 0 – 14g/day, middle: 15 – 38g/day, high: 38 – 168g/day

Europe PMC Funders Author Manuscripts

Eur J Clin Nutr. Author manuscript; available in PMC 2009 October 26.

Table 7

Means (SD) of cardiovascular risk factors in 1999 by thirds of processed meat intake in 1999 in men and women

	Men n=517				Women n=635			
Health outcomes 1999	**Thirds of processed meat intake in 1999[1]**			**ANOVA**	**Thirds of processed meat intake in 1999[2]**			**ANOVA**
Age 53 years	**Age 53 years**				**Age 53 years**			
	Low	**Middle**	**High**	***p***	**Low**	**Middle**	**High**	***p***
Total cholesterol, mmol/L	5.89 (0.94)	5.87 (1.17)	5.99 (0.95)	NS	6.08 (1.14)	6.08 (1.15)	6.22 (1.16)	NS
LDL cholesterol, mmol/L	3.50 (0.93)	3.50 (1.09)	3.53 (0.89)	NS	3.49 (1.05)	3.42 (0.97)	3.54 (1.08)	NS
HDL cholesterol, mmol/L	1.55 (0.63)	1.45 (0.43)	1.55 (0.65)	NS	1.9 (0.49)	1.86 (0.51)	1.86(0.50)	NS
Systolic bp, mm Hg	136.3 (18.3)	138.1 (19.6)	141 (19.0)	0.067	131.5 (17.9)	133.4 (20.5)	134.4 (18.9)	NS
Diastolic bp, mm Hg	85.4 (11.2)	86.0 (11.7)	87.6(10.8)	NS	81.1 (9.9)	81.8 (11.2)	82.9 (10.9)	NS
BMI, kg/m^2	26.0 (3.3)	26.8 (3.8)	26.8 (3.4)	0.051	25.6 (4.3)	26.6 (4.8)	27.3 (4.9)	0.001
Waist circumference, cm	93.6 (9.2)	96.6 (11.0)	96.4 (9.4)	0.009	81.0 (10.1)	83.5 (11.7)	85.0 (11.5)	0.001

bp = blood pressure

*1*Thirds of processed meat consumption; men: low: 0 – 15g/day, middle: 15 – 38g/day, high: 38 –127g/day

*2*Thirds of processed meat consumption; women: low: 0 – 10g/day, middle: 10 – 24g/day, high: 24 – 105g/day

Europe PMC Funders Author Manuscripts

Table 8

Means (SD) of cardiovascular risk factors in 1999 by thirds of intakes of red and processed meat combined in 1989 and 1999 in men and women

Health outcomes 1999	Men n=517				Women n=635			
	Thirds of red and processed meat intake in 1989[1], age 43 years			ANOVA	Thirds of red and processed meat intake in 1989[2], age 43 years			ANOVA
	Low	Middle	High	*p*	Low	Middle	High	*p*
Systolic bp, mm Hg	138.4 (19.3)	136.1 (17.1)	141 (20.3)	NS	133.3 (19.2)	132.3 (18.8)	132.7 (19.0)	NS
Diastolic bp, mm Hg	85.8 (10.6)	85.1 (11.0)	87.9 (12.1)	NS	81.8 (10.5)	81.7 (10.2)	81.9 (11.4)	NS
BMI, kg/m^2	26.0 (3.4)	26.5 (3.54)	27.0 (3.6)	0.027	26.1 (4.5)	26.5 (4.5)	26.7 (5.0)	NS
Waist circumference, cm	94.2 (9.7)	95 (9.7)	97.4 (10.3)	0.009	81.7 (11.0)	83.2 (10.6)	83.7 (11.5)	NS
Health outcomes 1999	**Thirds of red and processed meat intake in 1999[3], age 53 years**			**ANOVA**	**Thirds of red and processed meat intake in 1999[4], age 53 years**			**ANOVA**
	Low	**Middle**	**High**	***p***	**Low**	**Middle**	**High**	***p***
Systolic bp, mm Hg	136.2 (18.8)	137.2 (17.5)	142.1 (20.2)	0.014	132.4 (18.2)	131.1 (19.7)	134.9 (18.8)	NS
Diastolic bp, mm Hg	84.8 (11.3)	85.8 (10.5)	88.4 (11.7)	0.009	81.6 (10.3)	81.1 (11.1)	82.8 (10.7)	NS
BMI, kg/m^2	25.9 (3.1)	26.9 (3.9)	26.8 (3.5)	0.014	25.8 (4.6)	26.0 (4.4)	27.5 (4.9)	<0.001
Waist circumference, cm	93.0 (9.1)	96.8 (10.6)	96.7 (9.8)	<0.001	81.2 (11.0)	81.8 (10.0)	85.7 (11.6)	<0.001

bp = blood pressure

[1] Thirds of red and processed meat consumption 1989; men: low: 0 – 64g/day, middle: 64 –105g/day, high: 105 –377g/day

[2] Thirds of red and processed meat consumption 1989; women: low: 0 – 43g/day, middle: 43 – 77g/day, high: 77 –232g/day

[3] Thirds of red and processed meat consumption 1999; men: low: 0 – 48g/day, middle: 49 –86g/day, high: 86 –301g/day

[4] Thirds of red and processed meat consumption 1999; women: low: 0 – 30g/day, middle: 31 – 61g/day, high: 62 – 178g/day

Europe PMC Funders Author Manuscripts

Table 9

Significant associations between red and processed meat consumption in 1989 and 1999 and BMI and waist circumference of men and women measured in 1999

	Men n=517		Women n=635	
BMI at age 53 years	**Beta (SE)**	***p***	**Beta (SE)**	***p***
Red meat 1989 at age 43 years	0.008 (0.005)	NS	0.009 (0.006)	NS
Processed meat 1989 at age 43 years	0.015 (0.006)	0.009[a]	0.004 (0.008)	NS
Combined meat 1989 at age 43 years	0.013 (0.003)	<0.001	0.013 (0.005)	0.008[b]
Red meat 1999 at age 53 years	0.008 (0.005)	NS	0.015 (0.007)	0.035[b]
Processed meat 1999 at age 53 years	0.007 (0.007)	NS	0.027 (0.011)	0.018[b]
Combined meat 1999 at age 53 years	0.006 (0.004)	NS	0.018 (0.006)	0.002[a]
Waist circumference at age 53 years	**Beta (SE)**	***p***	**Beta (SE)**	***p***
Red meat 1989 at age 43 years	0.027 (0.015)	0.045[c]	0.033 (0.015)	0.033
Processed meat 1989 at age 43 years	0.031 (0.016)	0.037[c]	0.042 (0.02)	0.047
Combined meat 1989 at age 43 years	0.034 (0.009)	<0.001	0.035 (0.012)	0.003
Red meat 1999 at age 53 years	0.029 (0.015)	0.049	0.024 (0.018)	NS
Processed meat 1999 at age 53 years	0.034 (0.02)	NS	0.068 (0.027)	0.012
Combined meat 1999 at age 53 years	0.022 (0.01)	0.03[b]	0.037 (0.013)	0.006

All adjusted for socio-economic status, region of residence, smoking and alcohol consumption in 1999. Meat consumption in 1989 adjusted for energy intake in 1989; meat consumption in 1999 adjusted for energy intake in 1999.

No superscript = No other significant variables in model

[a]Model included alcohol consumption p<0.05, smoking p<0.05

[b]Model included alcohol consumption p<0.05.

[c]Model included alcohol consumption p<0.005, region p<0.05.

Europe PMC Funders Author Manuscripts

Table 10

Significant associations between red and processed meat combined consumption in 1989 and 1999 and blood pressure of men and women measured in 1999

Systolic bp, mm Hg	**Beta (SE)**	***p***	**Beta (SE)**	***p***
Red and processed meat 1989 at age 43 years	0.02 (0.018)	NS	0.018 (0.021)	NS
Red and processed meat 1999 at age 53 years	0.04 (0.02)	0.036[a]	0.032 (0.023)	NS

Diastolic bp, mm Hg	**Beta (SE)**	***p***	**Beta (SE)**	**NS**
Red and processed meat 1989 at age 43 years	0.017 (0.011)	NS	0.015 (0.011)	NS
Red and processed meat 1999 at age 53 years	0.023 (0.011)	0.043[a]	0.011 (0.013)	NS

[a]Model included alcohol consumption p<0.05, socio-economic status p<0.05