Red Meat and Health

Getting to the Heart of the Matter

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Consumption of red meat in the United States has progressively declined over the past 35 years. This occurred in conjunction with public recommendations to reduce red meat intake, based mainly on associations between higher red meat intake and increased chronic disease risk. This narrative review presents and discusses results from both observational cohort studies that focus on cardiometabolic disease development and mortality and randomized controlled trials that focus on cardiometabolic disease risk factors. This review will also address the potential effect of categorizations of red meat and processed meats on our understanding of cardiometabolic health implications of consuming red meat. Nutr Today. 2017;52(4):167–173

INTRODUCTION

Cardiometabolic disease risk refers to the chances of developing cardiovascular disease (CVD) or type 2 diabetes. More than 50% of the US population aged 19 years or older has dyslipidemia and/or hypertension, which are modifiable CVD risk factors,[1] whereas approximately 27% of the adult population is prediabetic, assessed by clinical measures of insulin-mediated glucose control.[2] Each year, 735 000 and 610 000 Americans experience a myocardial infarction and CVD-related mortality, respectively.[3] In the United States, 1.4 million Americans receive a diagnosis of diabetes annually, with 90% of those cases being type 2 rather than type 1 diabetes.[2] Importantly, CVD-related mortality is 1.7 times more common in adults with diabetes compared with those without diabetes.[2]

There are adaptable lifestyle practices that can reduce cardiometabolic disease risk, including consumption of a healthy eating pattern. The *Dietary Guidelines for Americans* often recommend reducing red meat consumption (no more than approximately 3–4 servings per week, 2–3 oz per serving) to lower cardiometabolic disease risk. There are other potential reasons to consider how much red meat to consume, such as cancer risk[4] and environmental sustainability[5]; however, this brief narrative review will focus on cardiometabolic disease risk. The purpose of this narrative review is to summarize the evidence about the potential implications of consuming higher amounts of red meat on cardiometabolic disease development, related mortality, and the associated risk factors by comparing results from observational cohort studies and experimental randomized controlled trials.

BUT FIRST, WHAT IS RED MEAT?

Red meat can be defined by (1) a technical meat science perspective addressing the muscle fiber type and myoglobin content of meat, (2) an agricultural perspective of animal source, and (3) an industry perspective of meat processing. The *2015–2020 Dietary Guidelines for Americans* defines red meats as "all forms of beef, pork, lamb, veal, goat, and nonbird game (eg, venison, bison, elk)." Lean meats, inclusive of lean red meats, "contain less than 10 g of total fat, 4.5 g or less of saturated fat, and less than 95 mg of cholesterol." Unprocessed meats are preserved by refrigeration or freezing only, whereas processed meats are preserved by smoking, curing, salting, and/or the addition of chemical preservatives.[6]

As stated by the 2015 Dietary Guidelines Advisory Committee, classification of meat, or red meat, throughout scientific literature is inconsistent. For example, when assessing dietary intake, researchers often classify red meat with processed meat, which has been defined as "total meat"[7] or "red meat."[8] More recently, researchers classify unprocessed red meat independently of processed red and white meats,[7,9] which still causes discrepancies. For example, "beef, pork, or lamb as a sandwich or mixed dish" is seen categorized as unprocessed red

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meat[10]; however, sandwich meats and mixed dishes (such as pizza) can be prepared with processed meats. In this narrative review article, we are limited by the definitions stated in each research article.

RED MEAT DIETARY GUIDANCE AND INTAKE IN THE UNITED STATES

The *Dietary Guidelines for Americans*, first released in 1980, provide evidence-based recommendations to promote a healthy lifestyle and reduce chronic disease risk. The guidelines are mandated by the US Congress to be updated every 5 years by the US Department of Health and Human Services and the US Department of Agriculture (USDA) with help from a scientific advisory committee of expert nutrition scientists (to see the scientific report of the 2015 Dietary Guidelines Advisory Committee and the *2015–2020 Dietary Guidelines for Americans*, go to https://health.gov/dietaryguidelines/). One key message of the first *1980–1985 Dietary Guidelines for Americans* was to reduce total fat, saturated fat, and cholesterol intakes to decrease CVD risk. This recommendation was based on, at the time, emerging positive associations between these nutrients and total blood cholesterol concentrations.[11] To support this dietary goal, Americans were encouraged to choose lean protein sources. Although the *1980–1985 Dietary Guidelines for Americans* did not explicitly suggest limiting red meat consumption, healthcare professionals began recommending consumption of white meat rather than red meat to lower total and saturated fat intakes. This period coincides with a drop in total red meat intake matched by a rise in poultry intake in the United States, as shown by food availability data adjusted for estimated losses (Figure 1).

The concept of a healthy eating pattern, defined as a combination of foods and beverages recommended for consumption to reduce chronic disease risk, was first introduced by the *Dietary Guidelines for Americans* starting in 2005. Throughout the evolution of these eating patterns such as the Dietary Approaches to Stop Hypertension (DASH) and the USDA's Healthy Mediterranean-Style Eating Pattern, red meat recommendations were explicitly or implicitly presented in various food groups and recommended amounts (Table 1). Assuming an average serving size of red meat is 2 to 3 oz, as stated by the American Heart Association, these recommendations are equivalent to less than 1 serving of red meat per day; Americans typically consume approximately 1 oz above this quantity (Figure 2). The *2010–2015 Dietary Guidelines for Americans* includes a specific "meat" ounce recommendation (assumingly red meat based on the other food groups included in the eating patterns), but the 2005–2010 *Dietary Guidelines for American* and the *2015–2020 Dietary Guidelines for American*'s red meat intake recommendation is ambiguous. The *Dietary Guidelines for Americans* also emphasize that protein sources, particularly meats, should be consumed in lean forms.

REVIEW OF THE EVIDENCE

Recommendations to limit red meat consumption are mostly based on evidence from long-term observational cohort studies of humans' eating habits. This type of prospective study design, such as the Nurses' Health Study, observes a

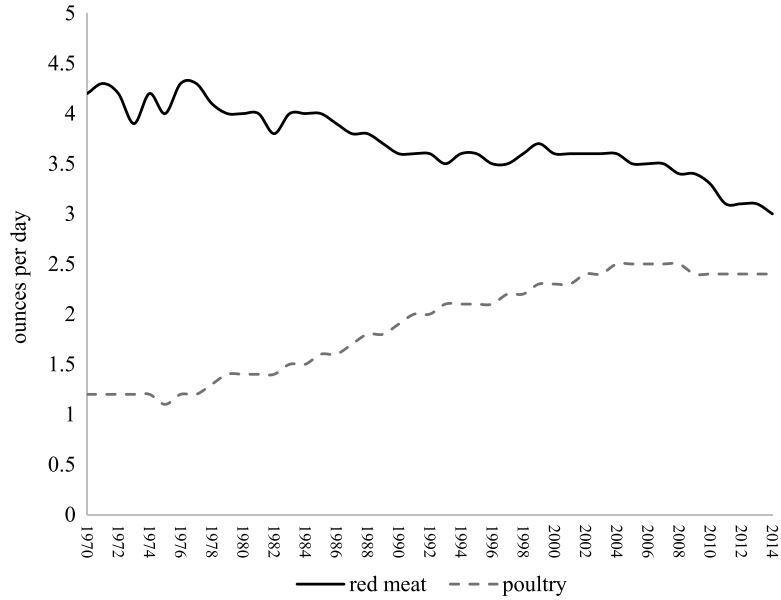

FIGURE 1. Red meat and poultry approximate intake data over time. Data are adapted from the US Department of Agriculture's Economic Research Service and are derived from food availability adjusting for food spoilage, plate waste, and other losses (https://www.ers.usda.gov/data-products/food-availability-per-capita-data-system/food-availability-per-capita-data-system/#Loss-Adjusted%20Food%20Availability).

TABLE 1 History of Red Meat Recommendations in the *Dietary Guidelines for Americans* Healthy Eating Patterns

Source	Food Group	Recommendation
2005–2010 Dietary Guidelines for Americans healthy eating patterns	Meat and beans (poultry and fish included)	5.5 once-equivalents or <6 oz of meat, poultry, and fish per day with 4-5 servings per week of nuts, seeds, and dry beans
2010–2015 Dietary Guidelines for Americans healthy eating patterns	Meat (with separate food groups for poultry and fish)	1.4–1.8 oz/d
2015–2020 Dietary Guidelines for Americans healthy eating patterns	Meats, poultry, and eggs	26 ounce-equivalents per week

group of people over time and relates their eating habits to whether they develop a disease (ie, type 2 diabetes diagnosis or a CVD-related incident such as a stroke) or related mortality. Observational study designs can detect associations between these 2 variables but cannot confirm causality. To determine cause and effect, tightly controlled randomized clinical trials are conducted. This type of study design isolates 1 dietary variable to determine its effect on disease risk factors, such as blood total cholesterol.

Randomized controlled trials are rarely conducted long enough to assess disease development or mortality because of ethical and practical reasons. Because of this, clinical trials usually measure intermediate disease risk factors such as blood lipids (total cholesterol and triglycerides), lipoproteins (low-density lipoprotein cholesterol and high-density lipoprotein cholesterol), blood pressures, and indicators of insulin-mediated glucose control such as fasting blood glucose and insulin concentrations. For this section of the review, we will compare results from commonly cited meta-analyses, which assess either associations between red meat consumption and cardiometabolic disease development and related mortality via data from epidemiological cohort studies, and the effects of consuming red meat on cardiometabolic disease risk factors via data from randomized controlled trials.

The categorization of red and processed meat as one variable may be a driver for the inconsistencies regarding red meat intake and cardiometabolic disease risk because total red meat consumption is inconsistently associated with a higher risk of CVD development[7,12–14] or CVD-related mortality.[12] However, the story is clearer when these 2 variables are assessed individually. Meta-analyses assessing unprocessed red meat consumption suggest little to no increased risk of developing CVD[9,13] or CVD-related mortality[15] with higher intakes. However, 6 of 8 entries in Table 2[7,9,12–15] showed an increased risk of CVD development and CVD-related mortality with higher processed meat intake (which is inclusive of processed white meats and processed red meats). Consuming 50 g (~2 oz) of processed meat per day showed up to a 42% increased risk of CVD development,[7,9] and consumption of the highest versus lowest quintile of processed meats showed up to an 18% increased risk of CVD-related mortality.[12] Therefore, the inconsistencies associating total red meat consumption with an increased CVD disease risk may be driven by the grouping of unprocessed red meats with processed meats. Results from randomized controlled trials complement the weak association between unprocessed red meat consumption and CVD development. A recent meta-analysis of randomized controlled trials in which the participants consumed mainly unprocessed beef and pork support that total red meat consumption does not influence CVD risk factors, specifically blood total, low-density lipoprotein, or high-density lipoprotein cholesterols, triglycerides, or blood pressure.[17] Another meta-analysis concluded that consuming unprocessed beef, independent of all other red and processed meats, did not differentially affect blood lipids or lipoproteins compared with consuming poultry and/or lean fish.[18] Both of these analyses lack assessment of processed versus unprocessed meats because of the paucity of experimental data on this topic. There is a need for future randomized controlled trials to assess the health effects of consuming unprocessed versus processed red and white meats on CVD risk factors.

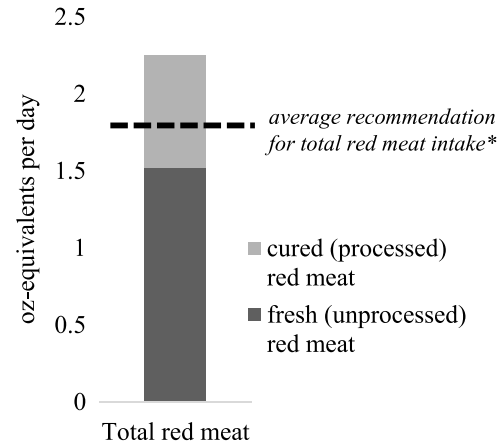

FIGURE 2. US red meat consumption versus the average recommendation. *The average red meat intake recommendation is based on eating patterns available from the *2005–2010*, *2010–2015*, and *2015–2020 Dietary Guidelines for Americans*.

TABLE 2 Summary of Meta-analyses of Prospective Cohort Studies Assessing the Association Between Red Meat Consumption and Cardiometabolic Disease Risk

Parameter	Red Meat Category	Relative Risk
Stroke	Total red meat	11% Increased risk per serving[a] per day increase[13,b]
		No increased risk per 100 g/d[7,c]
	Unprocessed red meat	9% Increased risk in the highest vs lowest consumption categories[14,b]
		No increased risk per serving[a] per day increase[13,c]
	Processed red meat	13% Increased risk per serving[a] per day increase[13,b]
		No increased risk per 50 g/d[7,c]
		14% Increased risk for highest vs lowest quintile[14,b]
Coronary heart disease	Total red meat	No increased risk per 100 g/d[7,c]
	Unprocessed red meat	No increased risk per 100 g/d[9,c]
	Processed red meat	42% Increased risk per 50 g/d[7,9,b]
CVD-related mortality	Total red meat	No increased risk for ischemic heart disease mortality in the highest vs lowest quintiles[12,c]
		16% Increased risk for all CVD-related mortality in the highest vs lowest consumption quintiles[12,b]
	Unprocessed red meat	No increased risk per 100 g/d[15,c]
	Processed red meat	15% Increased risk for all CVD-related mortality per 50 g/d[15,b]
		18% Increased risk for all CVD-related morality in highest vs lowest consumption quintile[12,b]
		No increased risk for ischemic heart disease morality in highest vs lowest consumption quintile[12,c]
Type 2 diabetes mellitus development	Total red meat	No increased risk per 100 g/d[7,c]
		20% Increased risk per 120 g/d[16,b]
		21% Increased risk in highest vs lowest consumption quintile[16,b]
	Unprocessed red meat	19% Increased risk per 100 g/d[9,10,b]
	Processed red meat	19% Increased risk per 50 g/d[7,b]
		41% Increased risk per 50 g/d[16,b]
		51% Increased risk per 50 g/d[9,10,b]
		57% Increased risk for highest vs lowest quintile consumption[16,b]

Abbreviation: CVD, cardiovascular disease.
[a]indicates that the serving size was not quantified.
[b]indicates a statistically significant result.
[c]indicates statistically insignificant results.

The observational evidence associating total red meat consumption with the development of type 2 diabetes is more consistent. Both meta-analyses assessing unprocessed red meat intake showed a 19% increased risk of developing type 2 diabetes when consuming 100 g (~3.5 oz) per day of unprocessed red meat.[9,10] In addition, all meta-analyses in

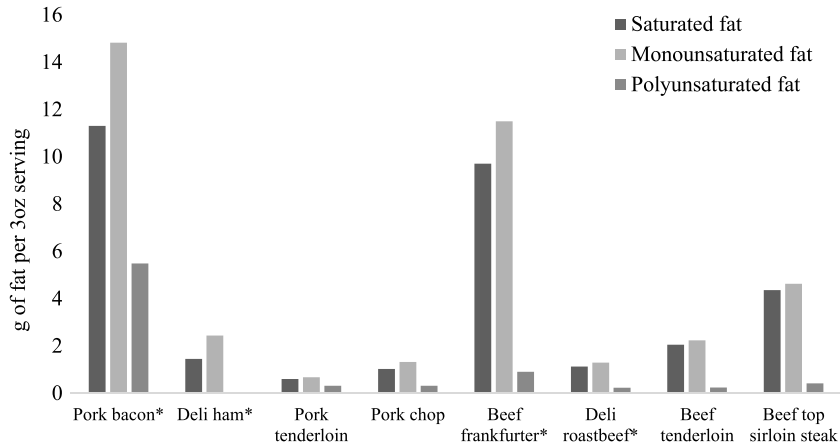

FIGURE 3. Fat content of commonly consumed red meats. Data adapted from the US Department of Agriculture Food Composition Database (https://ndb.nal.usda.gov/ndb/); * indicates processed red meats.

Table 2 assessing processed meat intake showed up to a 57% increased risk of developing type 2 diabetes when consuming 50 g of processed meat per day.[7,9,10,16] Apparently, there is no compilation of randomized controlled trials assessing the effects of red meat consumption on type 2 diabetes risk factors, such as fasting glucose and insulin concentrations or insulin resistance; this is a need for future meta-analysis. However, 2 recent randomized controlled trials showed that consuming higher amounts of red meat (~4-5.5 oz of beef or ~4 oz of pork[19] daily) within the context of a dietary approaches to stop hypertension showed no influence on fasting glucose and insulin concentrations.

Collectively, the available evidence from observational studies suggest little to no increased risk of CVD development or CVD-related mortality from consuming unprocessed red meats, but more research is needed to guide recommendations pertaining to type 2 diabetes risk. The data from observational studies support a positive association between increased cardiometabolic disease risk with processed meat consumption or more than 50 g per day, but there is a need for randomized controlled trials to further assess the effects of consuming processed meats on cardiometabolic disease risk factors.

POSSIBLE EXPLANATIONS

As stated previously, the *Dietary Guidelines for Americans* suggest that meat should be consumed in lean forms to keep the saturated fat content of the diet below the recommended 10% of daily energy intake allowance. None of the meta-analyses presented in the previous section investigated the effects of consuming lean versus nonlean red meats, and the evidence about saturated fat consumption and cardiometabolic health are inconsistent.[20] Although some cuts of red meat are relatively high in saturated fat compared with other protein sources, monounsaturated fats are the predominant fat source in red meats (Figure 3). Monounsaturated fats are consistently linked with positive cardiometabolic health outcomes,[21] especially in the context of a Mediterranean-style eating pattern.[22]

An issue with emphasizing lean protein sources is that many of the lean meat options available to consumers are processed (ie, fat-free or low-fat deli meats). Currently, the

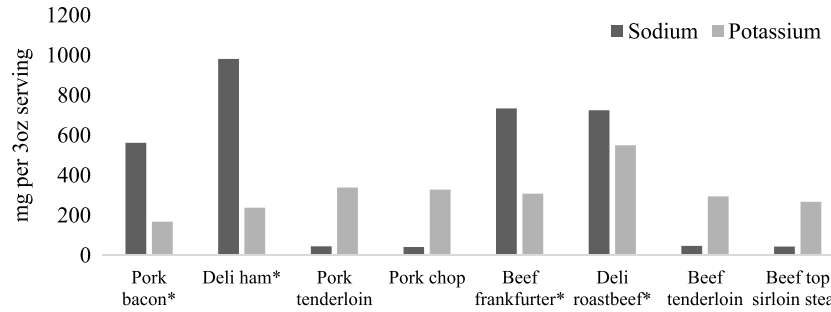

FIGURE 4. Sodium and potassium content of commonly consumed red meats. Data adapted from the US Department of Agriculture Food Composition Database (https://ndb.nal.usda.gov/ndb/). * indicates processed red meats.

2015–2020 Dietary Guidelines for Americans state that processed meats can be incorporated into a healthy dietary pattern as long as it is within recommended daily energy, saturated fat, and sodium intake ranges. As stated previously, there are consistent links between processed meat consumption and an increased cardiometabolic disease risk. Although more low-sodium options are now available, the sodium content of processed meats assessed in the 2005 to 2006 National Health and Nutrition Examination Survey cycle was approximately 4 times higher than unprocessed meats.[9] Sodium and potassium concentrations of commonly consumed red and processed meats are shown in Figure 4. It is estimated that the sodium content of processed meats can explain approximately two thirds of the increased cardiometabolic disease risk compared with unprocessed red meats.[7] This is likely attributable to higher sodium content contributing to increases in blood pressure. Processed meats also contain, on average, approximately 50% more nitrates per gram than unprocessed meats. Emerging evidence from cellular and animal models suggests that excess nitrates can increase vascular dysfunction[23] and impair glucose tolerance,[24] but there is a lack of data from human studies. Based on the evidence presented in this article, in the future, it may be beneficial for healthcare providers to educate their clients to distinguish between unprocessed and processed meats (red and white meats, alike) and to emphasize that unprocessed meats can be part of a healthy eating pattern to decrease cardiometabolic disease risk.

CONCLUSION

Organizations that promote healthy eating often recommend limiting red meat consumption because of associations between higher red meat intake and an increased risk of cardiometabolic disease development or related mortality. Unprocessed red meat is often grouped with processed meats (red and white), which may be a substantial driver to these positive associations. There is little to no apparent increased risk of cardiometabolic disease development or related mortality with higher unprocessed red meat consumption, but there is a consistent increased risk with higher processed meat consumption. This difference in risk assessment could be attributable to the approximately 400% and approximately 50% higher sodium and nitrate contents, respectively, in processed meats compared with unprocessed red meats. The data from randomized controlled trials complement the observational data regarding a relatively neutral effect of consuming upward of 3 servings per week of mostly unprocessed red meats on CVD risk factors. However, there is a paucity of research investigating the effects of processed meats on cardiometabolic disease risk factors, especially insulin-mediated glucose control. Importantly, none of the results presented in this article suggest that consuming more unprocessed red meat decreases the risks of cardiometabolic disease. Therefore, it is important to emphasize consuming a variety of lean unprocessed plant and animal protein sources as part of a healthy eating pattern.

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