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Diet and Nutrition: Implications to Cardiometabolic Health

Melissa Johnson*

College of Agriculture, Environment and Nutrition Sciences, Tuskegee University, USA

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***Correspondence:**
Dr. Melissa Johnson, PhD, College of Agriculture, Environment and Nutrition Science, 1200 W Montgomery Road, Tuskegee, AL 36088, USA; Telephone No: +1-334-727-8625; Email: mjohnson3@tuskegee.edu.

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Abstract

Cardiometabolic diseases and disorders continue to be the most significant and leading causes of morbidity and mortality in the United States, as well as globally. Among the cardiometabolic disorders, cardiovascular diseases (CVDs) have the greatest prevalence; other cardiometabolic disorders closely related to CVDs such as diabetes mellitus and Metabolic Syndrome (MetS) continue to contribute to the public health burden as well. Common risks for cardiometabolic disorders include biological (i.e. genetic predisposition, race, age, gender), demographic (socioeconomic status), dietary (dietary intake), behavioral (e.g., physical activity) and environmental (e.g., obesogenic, atherogenic, carcinogenic environments) characteristics. Paradoxically, dietary risk is both the most modifiable and least modifiable risk for certain diseases, as other modifiable and non-modifiable characteristics act in synergy to influence dietary intake. Although many inconclusive and conflicting research findings exist, the benefits of consuming a high quality diet are consistently valued and the role of diet in safeguarding cardiometabolic health cannot be underestimated. Diets rich in whole grains, non-starchy vegetables, and fruits, moderate in processed foods and refined grains, and consequently lower omega-6 to omega-3 fatty acid ratios appear to offer the greatest potential benefit. This mini review briefly summarizes the implications of diet and nutritional intake to cardiometabolic health.

Introduction

Often manifested as inflammatorily based diseases, cardiometabolic disorders may be one of the most irrefutable indicators of cardiometabolic health. Although no consensus definition of cardiometabolic health has been established, an individual's cardiometabolic health (and cardiorespiratory fitness) may inversely be related to risk for overweight/obesity, insulin resistance, type 2 diabetes mellitus, hypertriglyceridemia, blood pressure, C - reactive protein concentrations, and cardiovascular disease (CVD)[1-3]. The 2011-2014 prevalence of CVD was approximately 36.6% of US adults (20 years and older), with non-Hispanic African American males (46.0%) and females (47.7%) exhibiting a significantly greater prevalence than other ethnic groups[4]. Further, the dynamic connection between CVD and Metabolic Syndrome (MetS) cannot be denied as epidemiological evidence has demonstrated overlapping risk, comorbidities and outcomes for both conditions[5]. Steady increases in the prevalence of MetS, defined as a cluster of clinical risk factors (i.e., abdominal adiposity, hypertension, dyslipidemia, insulin resistance) that significantly increase the risk for CVD, type 2 diabetes mellitus and certain cancers, have occurred over the years[6,7]. It is estimated that MetS is prevalent in ~1 in 4 adults, with rates increasing with increasing age[8]. The increasing pervasiveness of these near epidemic conditions may undesirably affect public health, as risks for comorbidities and premature mortality significantly increase

with increasing prevalence. Therefore, mitigating the risks associated with cardiometabolic disorders and protecting cardiometabolic health is a paramount concern of public health professionals.

The Global Public Health Burden of Cardiometabolic Disease

Cardiometabolic disorders may not only adversely affect individual health but may compromise global public health as well. Unfortunately, racial and geographical variations in risk continue to exacerbate adverse cardiometabolic health outcomes[9], particularly among vulnerable, at-risk underserved populations. Inconsistencies in measures and outcomes of cardiometabolic health further contribute to health disparities and challenges to global public health[10]. Appropriately, the prevention of cardiometabolic disorders requires an integrative approach that considers biological, dietary, behavioral, environmental, and other key characteristics. Because disease risk spans across the nature-nurture divide (Figure 1), a multidisciplinary prevention and treatment protocol must consider all of the factors involved. Among the key factors, diet is one of the most critical, as the diet provides both essential and non-essential nutrients required for cardiovascular health, cognitive functioning, immune function, homeostasis and the sustaining of life.

Dietary/Nutrition Transition

Although abundant in animal products, the earlier hunter-gatherer diet was not considered atherogenic in

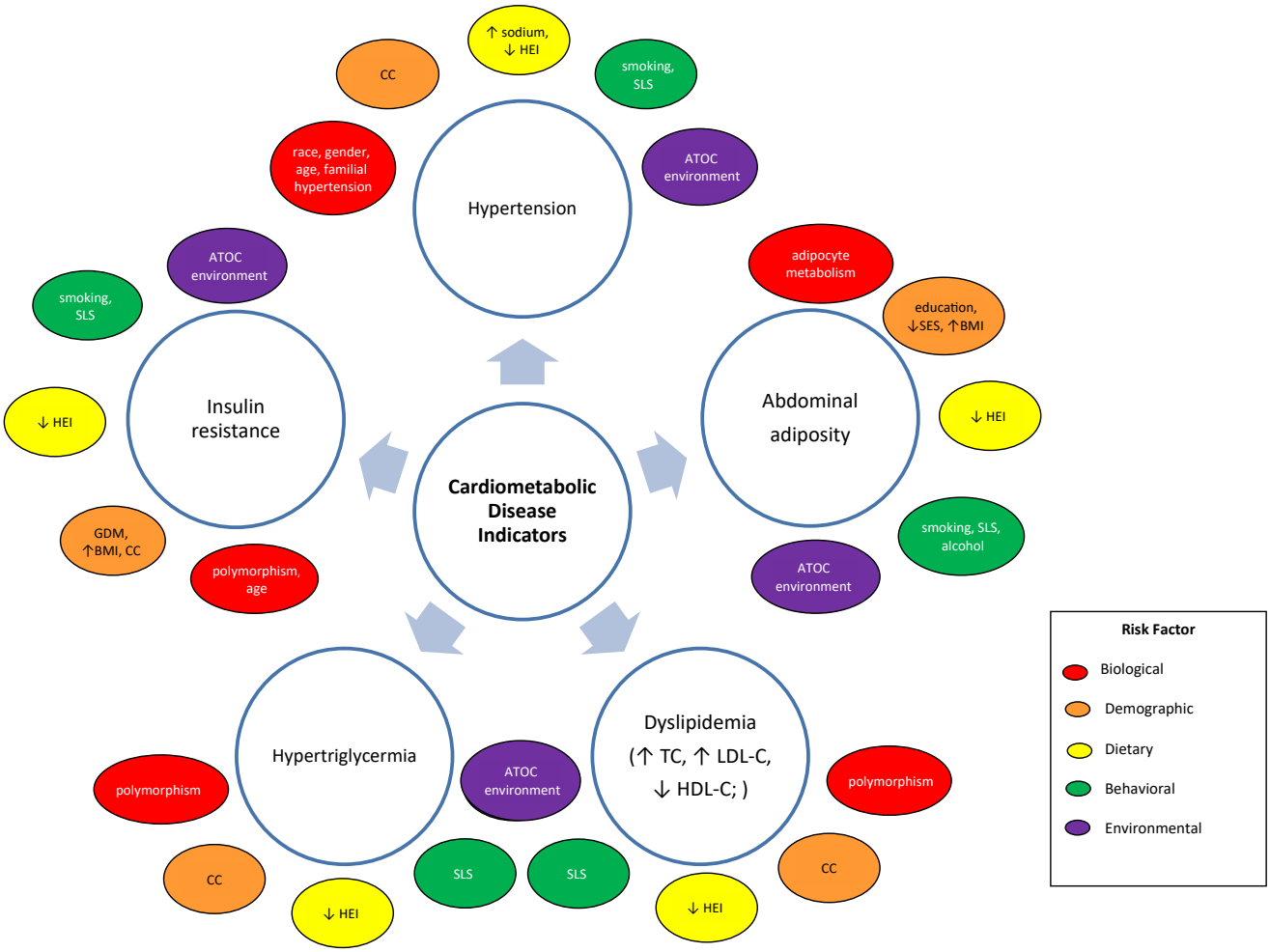

Figure 1. Simplified influence of biological, demographic, dietary, behavioral and environmental characteristics* on cardiometabolic disease indicators.

(*ATOC: atherogenic, toxicogenic, obesogenic, carcinogenic environment, an environment that facilitates the development of disease due to limited opportunity to engage in physical activity, acquire food (food desert), and receive preventive and/or treatment, health care resources and services, this environment may also be saturated with fast food restaurants/convenience stores (food swamp) and environmental toxins; BMI: Body Mass Index; CC: complication or comorbidity; GDM: gestational diabetes mellitus; HDL-C: high-density lipoprotein cholesterol; HEI: Health Eating Index, a measure of diet quality considering dietary variety and adherence to the Dietary Guidelines for Americans; LDL-C: low-density lipoprotein cholesterol; SES: socioeconomic status; SLS: sedentary lifestyle; TC: total cholesterol) ****This figure is not exhaustive and does not capture the vast risks for cardiometabolic disease.**

nature[11]. The complementary higher intakes of dietary fiber, antioxidants, phytochemicals, bioactive compounds, vitamins, mono- and polyunsaturated fatty acids -from plant sources and a lower omega-6/omega-3 fatty acid ratio could have in fact provided cardio-protection. Other lifestyle and environmental characteristics (e.g. greater physical activity, less exposure to environmental toxins, lack of cigarette smoking) are believed to have synergistically contributed to the cardiometabolic health of the hunter-gatherer as well. However, during the nutrition transition the "Westernization" of food production resulted in increased availability of processed foods, excessive intakes of calories, sugar, sodium and fat, and decreased diet quality[12]. This nutrition transition also resulted in a shifted increase in omega-6 fatty acids intake and an ensuing elevation in the dietary omega-6/omega-3 fatty acid ratio[13,14]. Consequently, the more Westernized dietary pattern (and lifestyle characteristics) have led to nutritional deficiencies/toxicities, physiological imbalances, chronic inflammation and disease[15,16]. Not surprisingly, these atherogenic, obesogenic, diabetogenic, carcinogenic, and toxicogenic diets have facilitated the pathogenesis of chronic, diet-related diseases such as CVD, diabetes, obesity and certain cancers[17,18]. Similar trends in chronic diet-related diseases such as malnutrition (over- and undernutrition), obesity, diabetes, dyslipidemia, hypertension and cardiovascular diseases are evident in both developed and developing countries[19]. Even more concerning is the observational evidence that trends in risk (e.g., dietary, socioeconomic, physical activity) emerge in childhood and continue into adulthood, predictive of cardiometabolic health[20-22].

Dietary Protection of Cardiometabolic Health

In light of the cardiometabolic threats introduced during the nutrition transition, the year-round availability of foods once considered seasonal, provides an opportunity to improve diet quality. The Mediterranean Diet, characterized as being rich in plant-based foods and having a lower omega-6/omega-3 fatty acid ratio, has yielded positive nutritional genomic effects on cardiometabolic health[23-25]. Non-nutritive bioactive compounds commonly found in plants may favorably influence nutrigenomics and shift the balance in the direction of health promotion and disease prevention by selectively amending specific metabolic pathways and attenuating inflammatory mechanisms implicated in disease pathogenesis[26,27]. In addition, research has demonstrated the ability of green leafy vegetables and the dietary omega-6/omega-3 fatty acid ratio to modify disease risk by influencing fatty acid profiles, blood pressure and markers of inflammation in an animal studeis[28,29]. Although caloric restriction has been endorsed to benefit metabolic health[30,31], it has been suggested that the macronutrient content of the diet, rather than total caloric intake, guides cardiometabolic health[32]. Interestingly, the influence of macronutrient intake on body fat, blood pressure and blood lipids, appears to vary among males and females[33]. In addition to the macronutrients, other dietary components may support cardiometabolic health by facilitating specific processes that optimize cardiometabolic functioning (Figure 2).

The Omega-6/Omega-3 Fatty Acid Ratio

The essential omega-3 and omega-6 polyunsaturated fatty acids have an array of physiological functions in cellular integrity and viability, immune function, inflammation and disease risk[34,35]. Although the ability of omega-3 fatty acids to prevent disease in epidemiology studies have yielded conflicting results[36-38], it has been suggested that omega-3 fatty acids may exert beneficial actions in reducing the risks associated with MetS by influencing oxidative status, glucose homeostasis, lipid metabolism and adiposity[39]. It has been proposed that reducing omega-6 fatty acid intake (below the current recommended levels of 5% to 10% of total energy) may potentially increase risk for CVD[40]. Considering this, it has been suggested that individuals consume "optimal" intakes of omega-3 and omega-6 polyunsaturated fatty acids that will not only prevent essential fatty acid deficiency, but decrease chronic disease risk[40]. Racial genetic variations in omega-6 and omega-3 fatty acid metabolism have been observed[41-44] and may offer a fractional explanation of the disparities in disease prevalence among certain racial groups.

The delicate balance in omega-3 and omega-6 fatty acids intake not only affects the production of eicosanoid metabolites that facilitate inflammatory and other homeostatic responses, but is central in the pathogenesis of diseases with an inflammatory epicenter, such as cardiovascular diseases, diabetes, degenerative diseases and mental disorders[45,46]. Imbalances in the ratio of omega-6 to omega-3 fatty acids may lead to imbalances in endogenous mediators and gene-nutrient interactions with biological consequences that may influence disease risk[47-49]. Adequate intakes of essential omega-3 and omega-6 polyunsaturated fatty acids, combined with dietary, behavioral and other lifestyle characteristics that promote health are believed to reduce – by default, risk for chronic disease as well[50-52].

Conclusions

The drastic transition from dietary patterns abundant in plant-based foods (e.g., whole grains, legumes, vegetables, fruits) and lean meats to less plant foods and more refined grains and processed foods, rich in calories, added sugar, sodium, and (total and saturated) fat, have unfavorably affected human health. The gradual decline in diet quality, together with other demographic, behavioral and environmental characteristics have resulted in

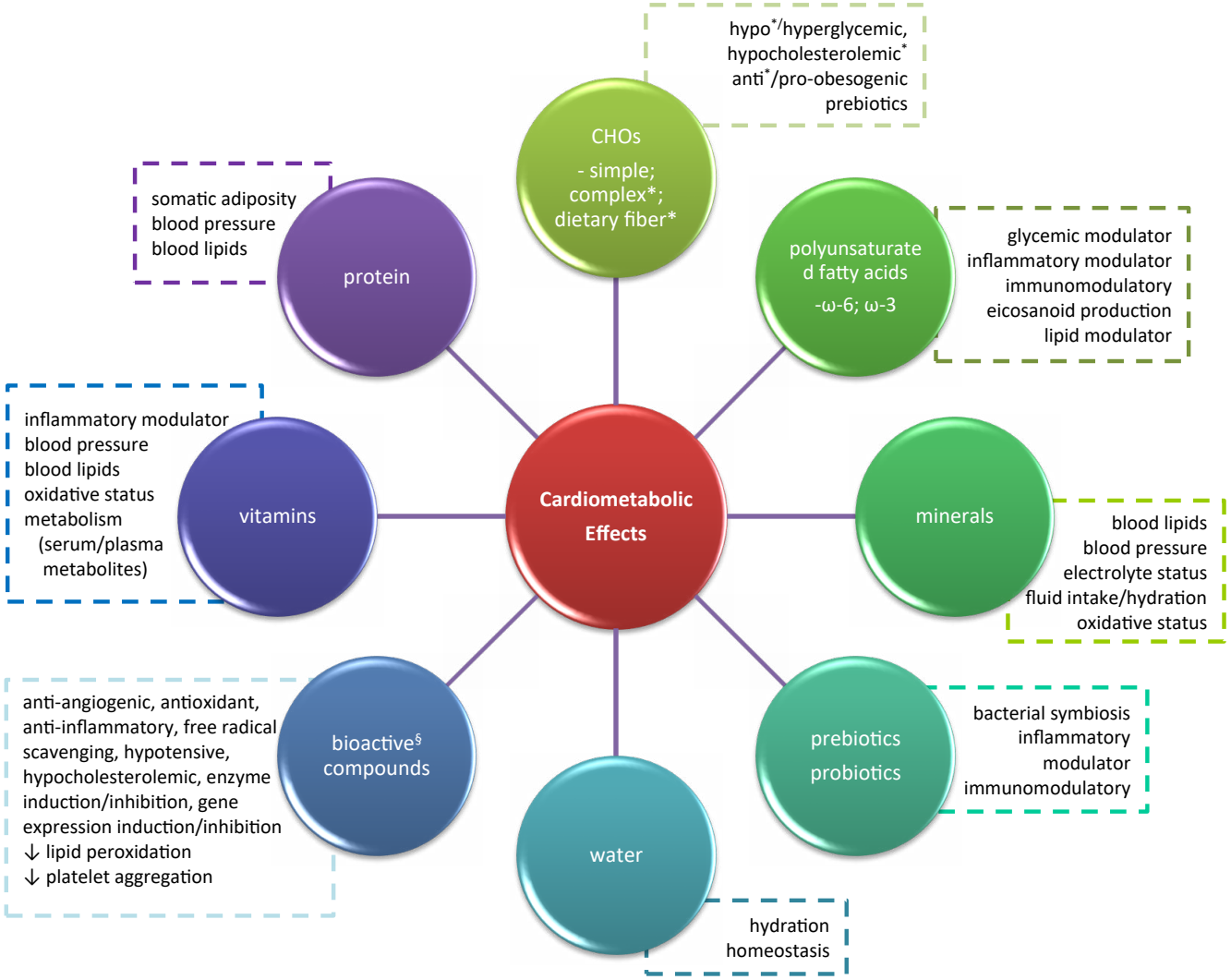

Figure 2. Potential cardiometabolic effects of dietary components[§].

[§] Non-nutritive components of food including, but not limited, to phytochemicals (carotenoids, flavonoids, isoflavones, polyphenols), isothiocyanate, phytosterols and tannins.

the emergence and sustaining of diet-related, chronic diseases. The initiation of specific metabolic pathways following nutrient intake expedite nutrigenomic and nutrigenetic outcomes that may beneficially or adversely affect cardiometabolic health. The typical Western dietary pattern exacerbates the risk for cardiometabolic disease, as it enhances a physiological microenvironment that encourages the initiation of pro-inflammatory pathways.

Because diet (and nutrition) directly affect the genome, transcriptome, proteome and metabolome, subsequent alterations in cardiometabolic health follow alterations in dietary intake. Dietary patterns aimed at reducing cardiometabolic risks should be balanced in plant-based foods, lean meats, essential omega-3 and omega-6 fatty acids and non-nutritive bioactive compounds. Optimizing nutritional intake and diet quality therefore becomes paramount to safeguarding cardiometabolic health. As cardiometabolic health is of public health concern, minimizing risk for adverse cardiometabolic health outcomes should begin during childhood, and quite possibly prior to conception.

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Conflict of Interest

The author declares that there is no conflict of interests.

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