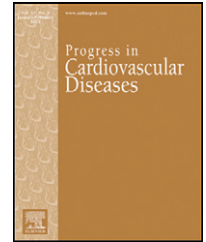


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Dietary Sodium and Blood Pressure: How Low Should We Go?



Linda Van Horn*

Department of Preventive Medicine, Northwestern University, Feinberg School of Medicine, 680 N. Lake Shore Drive, Suite 1400, Chicago, IL 60610

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ABSTRACT

Background: Sodium intake in the United States exceeds recommended amounts across all age, gender and ethnic groups. National dietary guidelines advocate reduced intake by at least 1,000 mg per day or more, but whether there is population-wide benefit from further reductions to levels of 1500 mg per day remains controversial.

Methods and Results: A brief review of current evidence-based dietary guidelines is provided and key prospective, randomized studies that report dietary and urinary sodium data are summarized. Dietary sources of sodium and eating patterns that offer nutritiously sound approaches to nutrient dense, reduced sodium intake are compared.

Conclusions: No studies suggest that high sodium intake at the levels of the population's current diet is optimal. On the contrary, national and international evidence and systematic reviews consistently recommend reducing sodium intake overall, generally by 1000 mg/day. Recommendations to reduce intakes to 2400 mg/d are generally accepted as beneficial. Whether further reductions to 1500 mg/d are useful, feasible and safe among specific subgroups in the population who are at increased risk of hypertension or stroke remains controversial and requires individualized consideration by patients and their health care providers.

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Introduction

According to the Dietary Guidelines for Americans, developed every five years based on in-depth, systematic, carefully conducted, quality controlled literature review, current dietary intake of sodium continues to exceed recommended amounts by the vast majority of the population across all age, sex, ethnic and economic groups.¹ While current population-wide recommendations advocate less than 2300 mg sodium per day and worldwide recommendations advocate less than 2000 mg/d, questions regarding the merits of recommendations less than that have been raised.^{2–4} The 2010 US Dietary Guidelines

Advisory Committee (USDGAC) and the American Heart Association (AHA) recommended sodium intake of 1500 mg for those who are over the age of 51, African American and/or already diagnosed with hypertension (HTN), but recent publications have questioned the validity of these recommendations and have even raised concerns about potential harm from dropping sodium intake below these levels.^{5–7} Current population intake of sodium is over 3400 mg/d, and few would disagree that reduction would benefit the majority of Americans, but exactly how much to reduce intake and by whom remain questions that generate considerable debate across different segments of clinical research and practice. When the

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* Address reprint request to Linda Van Horn, PhD, RD, Professor, Preventive Medicine, Associate Dean, Faculty Development, Department of Preventive Medicine, Northwestern University, Feinberg School of Medicine, 680 N. Lake Shore Drive, Suite 1400, Chicago, IL 60610.

E-mail address: lvanhorn@northwestern.edu.

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Abbreviations and Acronyms

AI = Adequate Intake
AHA = American Heart Association
BP = blood pressure
CV = cardiovascular
CHD = coronary heart disease
DASH = Dietary Approaches to Stop Hypertension
g/d = gram/day
HF = heart failure
HTN = hypertension
IOM = Institute of Medicine
mg = milligram
mm = millimeter
NHANES = National Health and Nutrition Examination Survey
RCT = randomized controlled trial
USDG = United States Dietary Guidelines
SDGAC = United States Dietary Guidelines Advisory Committee
UL = upper limit
WHO = World Health Organization

Centers for Disease Control and Prevention commissioned the Institute of Medicine (IOM) in 2012 to critically review the study designs, methodologies and results of the studies assessing the relationship between sodium intake and health outcomes, specifically major cardiovascular (CV) disease (CVD) events and mortality rather than the surrogate marker, blood pressure (BP), further debate arose. Since the publication of the most recent IOM report in 2013⁵ further questions regarding the optimal sodium recommendations for the population have escalated.

This paper offers a brief review of this topic, with a summary of the literature that underlies the rationale for developing the 2010 versus the 2015 United States Dietary Guidelines (USDG) on sodium intake, including

suggested causes for debate regarding these decisions and why there are lingering concerns. Both nutritional and epidemiological issues are addressed and suggested research gaps needing further attention are summarized.

Current intake of sodium and how it is assessed

Fig 1 illustrates the US sodium intake as reported by the 2015 USDG Advisory Committee by age and gender. Assessment of dietary sodium intake is challenging due to its ubiquitous presence in the food supply, particularly in processed foods.^{8,9} Despite many studies and attempts to simplify accurate assessment of individual sodium intake, multiple 24-hour urine collections remain the optimal standardized method for estimating dietary sodium intake.^{10,11} This complex methodology is often identified as the rate limiting step in conducting well-designed studies and randomized clinical trials to better and more definitively address lingering questions regarding dietary sodium and its impact on BP.¹²

Cost, quality control, and participant burden represent major deterrents from incorporating these methods and efforts to abbreviate, simplify and otherwise minimize these

limitations have perpetuated without satisfactory alternatives.¹² Overnight, spot and first morning urine collections have been suggested as viable alternatives, but none of these are considered as reliable as the mean of multiple 24 hour urine collections for individuals, although recent studies have offered encouraging results for estimating average sodium intake among Western (North American and European) adults aged 20–59.¹³

On the basis of 2009–2010 National Health and Nutrition Examination Survey (NHANES) data, the average sodium intake for all persons age 2 years and older was 3463 mg/d.¹⁴ This is more than double the Adequate Intake (AI) level of 1500 mg/d and almost 1000 mg/d more than the upper limit (UL) established for adults by the IOM,¹⁵ or the recommended amount specified by the Dietary Guidelines for Americans, the AHA,¹⁶ Healthy People 2020¹⁷ and the World Health Organization (WHO).¹⁸ Despite ongoing advice to reduce the population intake of sodium, average intakes have remained unchanged over the past fifty years.¹⁹ In children, the UL is less than 2300 mg/d but the vast majority of children, even 2–5 year olds, consume well above that amount (see Fig 2). On average, it was estimated from NHANES 2005–2008 data that children age 2–18 years consume 3056 mg of sodium per day²⁰ and furthermore, every 390 mg Na/d was associated with 74 g/d greater intake of fluid, including 32 g/d higher intake of sugar sweetened beverages (SSBs), among those who consumed SSBs, thereby linking added calories and added sugar to increased sodium intake as well.

Sodium, BP and HTN

Excess sodium intake is linked with HTN, CVD and stroke as well as other chronic diseases.²¹ In comparing risk factors associated with deaths world-wide, the WHO reported that elevated BP is the leading cause of death, more than tobacco use, or physical inactivity or overweight and obesity.¹⁸ Almost a billion people in the world have HTN or pre-HTN, with countries like China contributing more than half of these individuals. In the United States, nearly one in three adults is diagnosed with HTN, and the lifetime risk after age 50 years is 90%.²² Over 80% of those who have HTN do not know it and 47.5% do not have it controlled.²³ Systematic reviews and meta-analyses have consistently reported that high sodium intakes are associated with higher population-wide BP levels.^{9,24} Also, meta-analyses involving 34 trials reported that modest salt reduction for as little as four or more weeks, significantly reduced population systolic/diastolic BP levels in both hypertensive (–5.39/–2.82 mm Hg) and normotensive (–2.42/–1.00 mm Hg) individuals, respectively.²⁵ A clear dose–response relationship was further reported with greater reductions in sodium intake achieving greater BP lowering with expectations to reduce population-wide strokes, heart attacks and heart failure (HF).

Other recent meta-analyses based on urinary sodium data from 66 countries accounting for 74.1% of all adults in the world were conducted by the Global Burden of Diseases Nutrition and Chronic Diseases Expert Group.²⁶ Using comparative risk assessment, it was reported that in 2010, 1.65 million deaths due to CV causes were attributed to dietary sodium intakes above 2000 mg/d. Furthermore, 99.2% of the

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