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Can Dietary Sodium Be Modified by Physician's Advice? Data from Sodium and Potassium Intake among US Adults from 2003-2014

Guang Hao, ShaoyongSu, James Halbert, Xiaoling Wang, Gregory Harshfield, Gaston Kapuku*

Department of Population Health Sciences, Medical College of Georgia, Augusta University, Augusta, GA

***Corresponding author:** Gaston Kapuku, Department of Population Health Sciences, Medical College of Georgia, Augusta University, 1120 15th Street, HS 1721, Augusta, GA 30912, Tel: 706-721-4534; Fax: 706-721-7150; E-mail: gkapuku@augusta.edu

Abstract

Evidence has confirmed that high sodium and low potassium intake increases the risks of hypertension and cardiovascular disease, yet the recent changes of sodium and potassium intake have not been evaluated. The aims of this study is to examine recent trends in the intake of sodium and potassium in US adults in 2003- 2014 using the data from National Health and Nutrition Examination Surveys (NHANES), and to explore the effect of doctor's advice on salt reduction. Study participants were 24,198 US adults who had their 24-hour dietary recall data recorded twice. Fewer than 2% and 11-15% of US adults consumed <1500 and <2300 mg/d sodium. Further, less than 3% adults consumed ≥4300 mg/d potassium during 2003-2014. The estimated mean sodium and potassium intake did not significantly change over time. Overall, 47.1% US adults reported an action of salt reduction, and 21.2% were told by doctors to reduce the amount of sodiumin their diet. There was no statistically significant difference in salt reduction between participants with the cardio-metabolic disease who were told to reduce salt and those who were not (P=0.053). However, participants who reported taking action to reduce sodium consumption had 150 mg lower sodium intake compared with those who did not (P=0.013). In conclusion, the proportion of participants who meet the national recommendations for sodium and potassium intake was low and did not change over time during 2003-2014. Better strategies are needed to improve the physician effect on patient's sodium intake.

Keywords: Intake; Sodium; Potassium; Trend; Food; United States

Abbreviations: NHANES, National Health and Nutrition Examination Surveys; US, United States; BP, blood pressure; CV, cardiovascular;

Introduction

High blood pressure (BP) is well established as a major risk factor for cardiovascular (CV) disease, which is the leading causes of death and disability in adults worldwide[1]. Much evidence showed that increased sodium and decreased potassium intake are associated with high BP and CV disease[2,3]. Both prospective cohort studies and outcome trials have confirmed that a lower salt intake diet is related to a reduced risk of hypertension and CV disease[4]. Intervention studies have also shown that potassium supplementation reduces BP[5].

There has been a significant reduction of sodium from US households' packaged food and beverage purchases in the past 15 years[6]. However, national-representative data on the trends of sodium and potassium intake are limited. It is important to assess whether sodium and potassium intake has concomitantly changed over this time period. Therefore, we first examined recent trends in sodium and potassium intake in adults in 2003-2014 using the data from National Health and Nutrition Examination Surveys (NHANES). Second, we explored the effect of doctor's advice on salt and potassium intake. We hypothesized that the proportion of participants who met the national

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recommendations for sodium and potassium intake was low, and physician instruction to reduce sodium intake was effective in changing patient's sodium consumption.

Subjects and Methods

NHANES is a series of stratified, multistage, complex surveys designed to be representative of the non-institutionalized US population that are conducted by the National Center for Health Statistics (NCHS), Centers for Disease Control and Prevention[7]. NHANES data are released in 2-year cycles. The data included in this study were from six consecutive survey cycles during 2003-2014. We restricted our analyses to participants ≥ 20 years old. All participants provided written informed consent and the research ethics boards of the NCHS approved all protocols.

Cardio-metabolic disease was defined as having any of the following diseases: cardiovascular disease (self-reported history of coronaryheart disease, heart attack, angina, chronic heart failure, or stroke); diabetes (self-reported history of diabetes diagnosis, use of insulin or other diabetic medications, orglycohemoglobin ≥ 6.5%); chronic kidney disease (estimated glomerular filtration rate <60 mL .min^{-1}. 1.73 m^{-2} or urinary albumin/creatinine ratio <30 mg/g); hypertension (systolic BP ≥130 mm Hg, diastolic BP ≥80 mm Hg[8], or self-reported use of antihypertensive medication).

Data on dietary sodium and potassium intake were assessed using two 24-hour dietary recalls. The first recall was administered in person, followed by a second recall administered via phone 3–10 days later. Nutrient values were assigned to foods using the U.S. Department of Agriculture (USDA) Food and Nutrient Database for Diet Studies (FNDDS). Trained interviewers administered the 24-hour dietary recalls using the automated multi-pass method.

In 2011–2012 and 2013–2014, two new questions on sodium reduction were added (1. To lowers your risk for certain diseases, during the past 12 months have you ever been told by a doctor or health professional to: reduce the amount of sodium or salt in your diet? 2. To lower your risk for certain diseases, are you now doing any of the following: reducing the amount of sodium or salt in your diet?), which were used to assess the effect of doctor's advice on salt reduction. There were 8,681 participants (aged over 20 years) eligible for analysis.

Statistical analysis

We used the Software for Intake Distribution Estimation for the Windows Operating System (PC-SIDE, version 1.0; Iowa State University), which accounted for between- and within-person variations in sodium and potassium intake. We estimated the means and proportion of individuals who consumed <1500 or <2300 mg sodium/d or ≥4700 mg potassium/d) as recommended using Stata software version 12.1 (STATA Corp., TX, US)[9,10]. Data were also age-standardized by using the 2000 US Census as the standard population for comparison. A two-sided P< 0.05 was considered significant.

Results

Study participants were 24,198 US adults who had 24-hour dietary recall data recorded twice. Mean estimated daily sodium and potassium intakes were 3331-3484 and 2625-2743 mg among adults aged ≥20 y during 2003–2014. Fewer than 2% and 11-15% of adults consumed <1500 and <2300 mg/d sodium, as well as fewer than 3% adults consumed ≥4300 mg/d potassium during 2003-2014. Higher proportions of younger and cardio-metabolic individuals met the recommendations for sodium and potassium consumption (Table 1 and Table 2). For non-Hispanic black, the proportions that met the recommendations for sodium was higher, and the proportions that met the recommendations for potassium was lower compared with other ethnic groups. (Table 1 and Figure 1) Figure 2 shows the weighted age-adjusted proportions of sodium < 1500 and potassium intake ≥ 4300 mg/d, indicating the trends of sodium and potassium intake were stableduring 2003-2014.

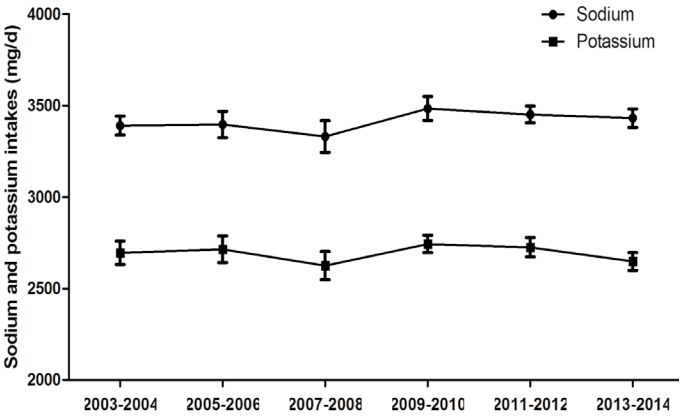

Figure 1: Weighted estimated mean of intake sodium and potassium in US adults, 2003-2014

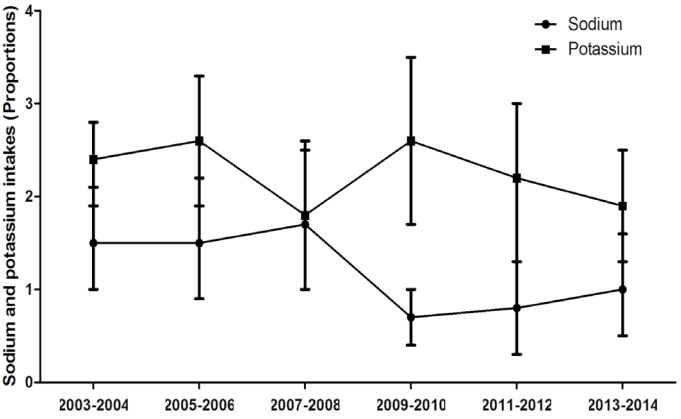

Figure 2: Weighted age-adjusted proportions of US adults who intake sodium <1500 and potassium ≥4300 mg/d, 2003-2014 Data were age-standardized by using the 2000 US Census as the standard population.

Table 1: Weighted proportions of US adults who intake sodium < 1500 and < 2300 mg/d, 2003-2014

	2003-2004 (n=3422)	2005-2006 (n=3365)	2007-2008 (n=4117)	2009-2010 (n=4602)	2011-2012 (n=3984)	2013-2014 (n=4708)	P value*
Sodium <1500 mg/d							
Overall	1.5(1.0-2.0)	1.5(1.0-2.0)	1.8(1.2-2.3)	0.7(.4-.9)	0.8(0.4-1.2)	1.0(0.6-1.5)	
Age							
20–30 y	1.2(0.3-2.0)	2.7(0.8-4.5)	2.1(0.8-3.3)	2.0(0.8-3.3)	1.4(0.0-2.8)	1.3(0.0-2.6)	
31–50 y	1.8(0.7-2.8)	1.5(0.8-2.1)	2.2(1.1-3.3)	0.5(0.1-0.8)	0.6(0.3-1.0)	1.4(0.6-2.3)	
51–70 y	1.8(1.0-2.6)	0.8(0.3-1.4)	1.4(0.8-2.0)	0.2(0.1-0.3)	0.9(0.1-1.7)	0.5(0.1-1.0)	
≥71	0.6(0.1-1.0)	1.9(0.4-3.4)	0.8(0.3-1.3)	0.5(0.0-1.0)	0.1(0.0-0.2)	0.8(0.1-1.5)	0.279
Race-ethnicity							
Non-Hispanic white	1.2(0.6-1.8)	0.8(0.4-1.3)	1.1(0.5-1.6)	0.5(0.2-0.8)	0.6(0.1-1.2)	0.9(0.3-1.5)	
Non-Hispanic black	2.4(1.1-3.7)	4.3(1.8-6.8)	3.4(1.7-5.0)	0.8(0.3-1.3)	1.5(-)	2.2(0.9-3.4)	
Mexican American	2.1(0.8-3.3)	4.2(2.2-6.1)	3.0(1.4-4.6)	2.0(0.6-3.4)	1.1(-)	0.7(-)	
Other	2.7(0.5-5.0)	1.8(0.1-3.5)	4.0(1.4-6.6)	0.6(0.1-1.0)	0.9(0.3-1.5)	0.9(.2-1.6)	<0.001
Cardio-metabolic disease							
No	1.6(0.9-2.3)	1.4(0.8-2.0)	2.0(1.1-2.8)	0.9(0.4-1.4)	1.0(0.2-1.8)	1.0(0.4-1.7)	
Yes	1.4(0.8-2.1)	1.6(0.9-2.4)	1.5(0.9-2.0)	0.4(0.2-0.6)	0.6(0.3-0.9)	1.1(0.6-1.5)	0.040
Sodium <2300 mg/d							
Overall	13.5(11.9-15.1)	13.7(12.2-15.2)	15.5(13.9-17.1)	11.3(10.1-12.6)	11.8(10.2-13.4)	11.9(10.5-13.3)	
20–30 y	13.4(10.6-16.2)	13.0(10.7-15.3)	16.3(13.5-19.0)	12.7(10.5-14.9)	12.8(10.2-15.4)	12.8(10.5-15.2)	
31–50 y	15.0(12.0-17.9)	12.6(10.0-15.1)	13.1(10.9-15.3)	8.9(7.1-10.8)	11.2(8.2-14.1)	11.3(8.8-13.7)	
51–70 y	15.2(11.8-18.7)	13.6(10.3-17.0)	14.3(11.2-17.4)	9.1(6.4-11.8)	7.9(5.6-10.3)	8.6(5.8-11.5)	
≥71	10.2(7.2-13.3)	17.6(13.2-22.0)	18.9(14.4-23.4)	14.2(10.5-17.9)	13.6(9.7-17.6)	13.3(10.0-16.7)	0.002
Race-ethnicity							
Non-Hispanic white	12.0(10.1-13.9)	11.5(9.7-13.2)	13.7(11.7-15.7)	9.2(7.7-10.8)	11.1(8.9-13.3)	10.5(8.7-12.3)	
Non-Hispanic black	18.9(15.2-22.6)	20.2(16.0-24.5)	22.5(18.8-26.2)	16.3(12.9-19.7)	14.9(-)	18.0(14.5-21.5)	
Mexican American	18.8(13.4-24.2)	23.2(18.8-27.6)	23.7(19.5-28.0)	19.9(16.3-23.5)	10.4(-)	12.2(-)	
Other	15.4(9.5-21.4)	16.7(11.0-22.5)	14.7(10.8-18.6)	13.1(9.5-16.7)	13.7(10.6-16.8)	13.5(10.0-17.0)	<0.001
Cardio-metabolic disease							
No	13.6(11.4-15.7)	13.5(11.5-15.6)	16.4(14.1-18.7)	12.1(10.3-13.9)	12.3(9.9-14.6)	12.4(10.4-14.3)	
Yes	13.4(11.0-15.7)	14.0(11.7-16.2)	14.5(12.4-16.6)	10.5(8.7-12.3)	11.4(9.3-13.4)	11.3(9.4-13.2)	<0.001

*Combined 6 cycles, and chi-squared test taking into account for the complex sampling design was used

- Missing 95% CI because of stratum with single sampling unit

Table 2: Weighted proportions of US adults who intake potassium ≥ 4300 mg/d, 2003-2014

	2003-2004 (n=3422)	2005-2006 (n=3365)	2007-2008 (n=4117)	2009-2010 (n=4602)	2011-2012 (n=3984)	2013-2014 (n=4708)	P value*
Overall	2.4(1.6-3.1)	2.6(1.8-3.4)	1.8(1.1-2.4)	2.6(1.9-3.3)	2.1(1.4-2.8)	1.9(1.3-2.5)	
20–30 y	2.8(1.2-4.4)	2.0(0.7-3.3)	2.7(0.3-5.2)	3.5(1.2-5.7)	3.1(1.2-5.0)	3.0(1.1-4.9)	
31–50 y	2.5(1.2-3.9)	3.6(2.0-5.1)	1.9(0.9-2.8)	2.8(1.7-4.0)	2.7(1.2-4.2)	1.1(0.4-1.8)	
51–70 y	2.1(0.9-3.4)	2.6(1.1-4.1)	1.4(0.4-2.4)	2.4(1.4-3.4)	1.3(0.6-2.0)	1.9(0.9-3.0)	
≥71	1.6(0.2-3.0)	0.4(0.0-0.8)	0.8(0.1-1.5)	0.9(0.1-1.8)	1.1(0.2-1.9)	2.1(0.9-3.3)	0.005
Race-ethnicity							
Non-Hispanic white	2.8(1.8-3.7)	2.8(1.8-3.8)	1.8(0.9-2.7)	2.7(1.8-3.6)	2.2(1.2-3.2)	1.7(1.0-2.5)	
Non-Hispanic black	0.6(0.0-1.4)	0.8(0.0-1.5)	1.0(0.0-2.1)	0.4(0.0-0.9)	1.5(-)	1.2(0.3-2.0)	
Mexican American	2.3(0.2-4.5)	2.5(0.8-4.1)	2.4(0.8-4.1)	3.8(1.7-5.8)	2.7(-)	2.2(-)	
Other	0.8(0.1-1.6)	3.4(-.8-7.6)	1.7(0.5-3.0)	2.9(0.9-4.9)	1.8(0.6-3.0)	2.9(1.3-4.5)	<0.001
Cardio-metabolic disease							
No	2.4(1.4-3.3)	3.1(1.9-4.4)	1.7(0.9-2.5)	2.2(1.3-3.2)	2.3(1.3-3.4)	1.6(0.9-2.4)	
Yes	2.4(1.2-3.5)	2.0(1.1-2.9)	1.9(0.8-2.9)	3.0(2.0-4.0)	1.9(1.0-2.8)	2.2(1.2-3.1)	0.002

*Combined 6 cycles, and chi-squared test taking into account for the complex sampling design was used

- Missing 95% CI because of stratum with single sampling unit

Overall, 21.2% (95% CI: 19.9-22.5) was told by doctors to reduce the amount of sodiumin their diet, and 47.1% (95% CI: 45.4-48.7) US adults reported taking action to reduce sodium intake. There were 23.9% (95% CI: 22.0-25.8) participants with the cardio-metabolic disease who were told to reduce the amount of sodium intake with 83.3% (95% CI: 80.2-86.4) reporting taking action to do so. There was no significant difference in sodium intake between participants who were told to reduce sodium intake and those who were not instructed to do so (3509.3[95% CI: 3414.4-3603.2] *vs*. 3486.6 [95%CI: 3430.7-3542.4 mg/d; P=0.053). However, the sodium intake in participants who reported taking action to reduce salt intake was significantly lower compared tothose who didn't take such action (3414.3[95% CI: 3352.1-3476.6] vs. 3567.5 [95%CI: 3494.7-3640.2 mg/d; P=0.013).

Discussion

Our hypotheses were partially accepted. In a representative sample of US adults, the proportions that met the national recommendations for sodium and potassium intake were extremely low, and the estimated mean sodium and potassium intake did not change over time during 2003-2014. Participants with cardio-metabolic syndrome who reported an action of salt reduction achieved only a reduction of 150 mg of sodium, confirming that behavioral changes in salt intake are daunting.

There is a large and growing burden of cardiovascular (CV) disease worldwide. The preventive interventions such as increasing physical activity and modifying diet are highly cost-effective in populations[11]. Of them, reducing salt intake has emerged as a leading target, with many guidelines recommending sodium intakes of 2.3 g/day or lower[12]. In our study, there was no statistically significant difference in salt reduction between participants with the cardio-metabolic disease who were told to reduce salt and those who were not, suggesting that patient-doctor interaction alone may not enough to curb salt consumption. Further, our data showed that participants who reported taking action to reduce sodium consumption had only 150 mg lower sodium intake compared with those who did not.Sodium intake originates from salt added to the table, beverages and/or processed foods. Harnack,et al.[13] reported that sodium added to food outside the home accounts for more than two-thirds of total sodium intake. Here in[14], the estimate sodium consumption was constant despite that nearly half of the participants reported taking action to reduce salt intake, and that there has been a decrease of the salt amount in packaged foods and beverage[15]. It will take the joined effort and support from stakeholders and changes in government policies to successfully reduce salt consumption as it has been reported in other countries[16]. It is obvious that the battle to reduce salt intake invites more aggressive actions, and a national strategy to reduce sodium in commercially processed foods is urgently needed.

People have paid far less attention to potassium, although the body of evidence supports that increase in dietary potassium intake outlined by current guidelines is an essential public health effort to prevent kidney disease, stroke, and CV disease[3,17]. The top sources of potassium in the diet include dairy, fruit, and vegetables. Unfortunately, the dairy consumption remains below daily recommendations, and fruits/vegetables consumption has declined over the past decade in the US[18]. Consistent with our results, fewer than 3% adults consumed ≥ 4300 mg/d potassium during 2003-2014. Therefore, public health interventions should aim to reduce sodium intake and simultaneously increase potassium intake through foods.

Our study provides the latest data on the trends of sodium and potassium intake in a representative sample of US adults. The proportion of Blacks meeting the recommendation for salt intake was greater than other ethnic groups; however, substantial effort is needed to promote high potassium intake in this population at high risk of developing hypertension and its end-target damage.

These results should be interpreted under the prism of some limitations including that sodium and potassium consumption assessment was based on subjective recall implying an increased likelihood of measurement error. Also, sodium and potassium from supplements and antacids, and table salt were not included in the analysis. Nevertheless, these findings call for a sustained effort to reduce sodium and promote potassium consumption leading to substantial health gain and health cost savings[19]. In addition, NHANES study did not collect the detail information of physician's advice on appropriateness, timing, and the applicability of messages Therefore, the lack of an effect of physician's advice requires prudence, and more specific studies areneeded to confirm the result.

Conclusion

In conclusion, recommendations for dietary sodium and potassium were not met during the last decade. Considering the high prevalence of CV disease and substantial health gain and net cost savings[19], strategies to reduce sodium in commercially processed foods and increase potassium intake are urgently needed in the United States.

Acknowledgments

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Conflict of Interest: None.

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