Dietary sodium intake among Canadian adults with and without hypertension

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Abstract

Introduction: Almost 30% of hypertension among Canadians may be attributed to excess dietary sodium.

Methods: We examined the average sodium intake of Canadians aged 30 years and over, with and without hypertension, by age, sex and diabetes status using 24-hour recall data from the 2004 Canadian Community Health Survey, Cycle 2.2, Nutrition. We compared absolute (crude) average sodium intake levels of those with and without hypertension to the 2009 Canadian Hypertension Education Program (CHEP) guidelines and adjusted average sodium intake between those with and without hypertension.

Results: Both those with and without diagnosed hypertension display average sodium intakes well above the 1500 mg/day recommended by the 2009 CHEP guidelines (2950 mg/day and 3175 mg/day, respectively). After confounding adjustment, those with hypertension have significantly higher average sodium intake (p = .0124). Stratified subgroup analyses found the average sodium intake among those with hypertension was higher for men between 30 and 49 years old (p = .0265), women between 50 and 69 years old (p = .0083) and those without diabetes (p = .0071) when compared to their counterparts without hypertension.

Conclusion: Better approaches are needed to reduce sodium intake in hypertension patients, as well as the general population.

Keywords: *sodium intake, salt intake, hypertension, high blood pressure, Canadian Hypertension Education Program, CHEP guidelines*

Introduction

Hypertension is one of the most important risk factors for heart diseases and stroke, two of the leading causes of death and hospitalization in Canada. An estimated 19% of Canadian adults aged 20 to 79 years are hypertensive, and an estimated 90% of the population will develop hypertension over their lifetime.[1,2] Almost 30% of hypertension among Canadians may be attributed to excess dietary sodium.[3] A dose-response relationship between sodium intake and elevated blood pressure has been repeatedly demonstrated in epidemiological studies.[4-6] Restricting dietary sodium intake lowers blood pressure among individuals with and without hypertension, with larger effects in reducing blood pressure in people with hypertension.[7,8] Sustained reduction in dietary sodium is associated with favourable cardiovascular outcomes, such as reduced cardiovascular events.[9]

The updated 2009 Canadian Hypertension Education Program (CHEP) guidelines for the management of hypertension recommend restricting dietary sodium to 1500 mg/day and not exceeding 2300 mg/day, in addition to eating a well-balanced diet.[10] These sodium intake thresholds are based on the nutrient reference values developed by the Institute of Medicine in 2004, with 1500 mg/day regarded as the Adequate Intake Level (AI) for healthy adults and 2300 mg/day the Tolerable Upper Intake Level (UL) for adults.[11] Intake above this UL may increase the risk of adverse health effects, though the report summarizes studies that have documented a clear dose response between sodium intake and blood pressure below this UL level.[11]

Despite published clinical guidelines and increased public health messages on limiting dietary sodium, a recent report from Statistics Canada reveals high average intake levels of sodium for Canadians of all ages.[12] While reducing sodium intake is important for everyone, it may be particularly critical for those with hypertension.

Are people with hypertension more likely to receive advice from their physicians concerning lifestyle changes, particularly reducing dietary sodium? As a result, do they reduce their sodium intake or, at the very least, not increase their sodium intake after learning they have hypertension? While it is feasible for people with hypertension to achieve and maintain a low salt diet over the long-term, the process is challenging and requires comprehensive steps to be successful.[13] To understand how much sodium is consumed by people with hypertension, we examined and compared average daily sodium intake between people with hypertension and without, after controlling for key potential confounding factors.

Methods

Sample

Data on individual daily sodium intake were collected using a 24-hour dietary recall interview that was conducted as part of the Canadian Community Health Survey

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(CCHS), Cycle 2.2, Nutrition (2004).[14] The CCHS 2.2 targeted people of all ages living in private dwellings in the 10 provinces, but excluded full-time members of the Canadian forces, and those in the 3 territories, reserves, institutions and remote areas. As such, it represented approximately 98% of the population in the ten provinces. The overall response rate for the CCHS 2.2, Nutrition (2004) was 76.5%. Statistics Canada and Health Canada have published detailed descriptions of the CCHS design, sampling and interview procedures.[14,15] Briefly, a total of 35 107 people completed an initial recall interview on all foods and beverages consumed from midnight to midnight before the interview. A five-step method based on the Automated Multiple-Pass Method developed by the US Department of Agriculture was used to optimize data collection.[16] The nutrient values in Canadian foods came from the Canadian Nutrient File (CNF), a comprehensive, computerized bilingual database containing up to 143 nutrients in over 5500 foods, including foods that are unique to Canada.[17] Only respondents aged 30 and older were included in our study.

Variables

Chronic conditions in the CCHS are self-reported and defined as "long-term conditions that are expected to last or have already lasted for 6 months or more and that have been diagnosed by a health professional." To determine hypertension status, participants were asked if they had "high blood pressure." Those with a response other than "yes" or "no" to this question were excluded from our analyses. Other variables included in the analyses were age, sex, body mass index (BMI), household education and income, smoking status, leisure time physical activity, diabetes status and total daily energy intake.

We established three age categories for this study: 30 to 49, 50 to 69, and 70 years and older. BMI was also categorized into three groups: under or normal weight (BMI < 25.0 kg/m^2), overweight (25 kg/m^2 ≤ BMI < 30.0 kg/m^2) and obese (BMI ≥ 30.0 kg/m^2). Total energy intake was the sum of all energy intakes from food sources in a single day in kilocalories (kcal).[17]

To define household education, we used the highest level of education among adult members of the household and set up the following four categories: less than secondary graduation, secondary graduation, some postsecondary education and postsecondary graduation. Dividing the total income for the household from all sources in the 12 months prior to the interview by the number of people living in the household, we established four income categories: low income, lower-middle income, upper-middle income and high income.[15] Due to a considerable number of no responses to the income question, a fifth income category (missing) was also created.

We defined three smoking status categories: current daily smokers (those who smoked cigarettes daily at the time of the interview and who had smoked 100 cigarettes or more over their lifetime); former smokers (those who had smoked daily but quit or still smoked occasionally at the time of the interview) and non-smokers (those who had never smoked or had smoked fewer than 100 cigarettes in their lifetime). Similarly, we categorized respondents into three physical activity groups based on their level of physical activity (frequency, duration and intensity) during leisure time over the previous 3 months: inactive, moderately active and physically active.[15]

Diabetes status was determined by whether or not a respondent reported a diagnosis of diabetes by a health professional.

Analyses

Our analyses were restricted to adults aged 30 and over, with a valid 24-hour dietary recall (n = 15 232). Of those, we eliminated 189 participants whose daily total energy intake was less than 500 kcal, another 21 who were missing hypertension status, and a further 6155 who did not have their weight and height measured (to calculate BMI), leaving a total of 8867 respondents in our analyses. We compared the baseline characteristics of respondents in terms of their self-reported hypertension status, including daily total energy intake, age, sex, BMI, leisure time physical activity, household education and income, smoking and diabetes status. We calculated average daily intake of sodium for those with and without hypertension, and estimated 95% confidence intervals (CI) for means using the bootstrap method to account for the complex multistage survey design. We determined statistical significance by comparing the 95% confidence intervals (CIs) for the means and compared average (crude) estimates of sodium intake for specific groups to the 2009 CHEP guidelines.[10]

We compared the average intake of sodium for people with and without hypertension using multivariate linear regression in order to account for extraneous differences in age, sex, BMI, total daily energy intake, household income and education, smoking, physical activity and the presence of diabetes between the two groups. We log-transformed daily sodium intake and energy intake to achieve the normal distribution required for statistical analyses and calculated adjusted sodium intake averages using marginal means and β coefficients from the multivariate linear regression equations. We determined statistical significance from the bootstrap method results. Moreover, we carried out stratified analyses by age and gender, and compared differences in mean sodium intake (unadjusted and adjusted) between hypertension and non-hypertension groups.

Results

Of the 8867 Canadians aged 30 years and over in the study, 2455 report having hypertension diagnosed by a health care professional—19% after applying appropriate survey weights. They are more likely to be older, obese, less educated, and a former daily smoker and have lower family income and diagnosed diabetes as a co-morbid chronic condition. (Table 1)

The unadjusted average daily intake of sodium is 2950 mg (95% CI: 2810–3090) for those with hypertension and 3175 mg (95% CI: 3078–3273) for those without (Table 2). The unadjusted mean sodium intake estimates for hypertensive and non-hypertensives of various age, sex and diabetes status groups are all well above the 2300 mg/day maximum set by the 2009 CHEP guidelines.[10]

TABLE 1
Baseline characteristics of participants (aged 30 and older) with or without hypertension.

	Hypertensive (95% CI)		Non-hypertensive (95% CI)	
Sample size (n)	2455		6412	
Weighted sample (n)	3 415 831		14 998 862	
Mean energy intake (kcal)	1870	(1809 – 1931)*	2140	(2089 – 2190)
Mean age (years)	63.6	(62.7 – 64.5)*	49.4	(49.1 – 49.8)
Male (%)	48.8	(45.4 – 52.3)	49.0	(48.2 – 49.8)
Mean BMI (kg/m^2)	29.6	(29.1 – 30.1)*	27.0	(26.8 – 27.3)
Age group (%)				
30–49 years	14.4	(11.2 – 7.6)*	58.2	(57.1 – 59.3)
50–69 years	49.4	(45.9 – 52.9)*	32.3	(31.1 – 33.4)
70+ years	36.3	(33.3 – 39.2)*	9.6	(9.0 – 10.1)
BMI (%)				
< 25 kg/m^2	21.8	(18.4 – 25.1)*	39.1	(36.7 – 41.4)
Between 25 kg/m^2 and < 30 kg/m^2	37.2	(33.6 – 40.8)	38.8	(36.5 – 41.1)
≥ 30 kg/m^2	41.0	(37.2 – 44.9)*	22.5	(20.2 – 24.1)
Smoking (%)				
Current daily smokers	18.8	(15.7 – 21.9)*	25.6	(23.5 – 27.8)
Former smokers	38.1	(34.5 – 41.6)*	30.2	(28.0 – 32.4)
Non-smokers	43.1	(39.3 – 47.0)	44.1	(41.6 – 46.5)
Leisure activity (%)				
Active	14.6	(11.9 – 17.3)	17.3	(15.4 – 19.1)
Moderately active	21.6	(18.6 – 24.7)	24.3	(22.3 – 26.3)
Inactive	63.8	(60.2 – 67.4)	58.5	(56.1 – 60.9)
Education (%)				
Less than secondary graduation	32.6	(29.4 – 35.7)*	18.2	(16.6 – 19.9)
Secondary graduation	18.2	(15.0 – 21.4)	18.5	(16.4 – 20.5)
Some post-secondary education	5.0	(3.6 – 6.3)	6.2	(5.1 – 7.3)
Post-secondary graduation	43.4	(40.0 – 47.0)*	56.0	(53.5 – 58.6)
Income (%)				
Low	12.2	(9.4 – 15.1)*	7.3	(6.0 – 8.5)
Lower middle	24.9	(21.4 – 28.5)*	18.2	(16.4 – 20.0)
Upper middle	32.3	(28.7 – 36.0)	33.3	(31.0 – 35.6)
High	22.8	(19.2 – 26.4)*	34.1	(31.6 – 36.7)
Missing	7.7	(5.8 – 9.6)	7.2	(5.9 – 8.4)
Diabetes (Yes, %)	16.6	(14.2 – 19.0)*	3.7	(2.8 – 4.6)

Data source: Canadian Community Health Survey, Cycle 2.2, Nutrition (2004). [14]
Abbreviations: BMI, body mass index; CI, confidence interval; *p*, statistical significance.
*$p < .05$

TABLE 2
Mean sodium intake (mg/day), crude and adjusted by multivariate linear regression among people with or without hypertension (aged 30 and older) and by age, sex and diabetes status.

	Hypertensive (95% CI)	Non-hypertensive (95% CI)	β coefficient	Standard error	*p*-value
All (30+ years) (n)	2455	6412			
Mean sodium intake (mg/day)	2950 (2810–3090)	3175 (3078–3273)			
Adjusted mean sodium intake (mg/day)	2877	2723	0.024	0.0094	.0124
Sex					
Male (n)	878	2812			
Mean sodium intake (mg/day)	3349 (3099–3599)	3580 (3432–3728)			
Adjusted mean sodium intake (mg/day)	3162	2972	0.027	0.0133	.0429
Female (n)	1577	3600			
Mean sodium intake (mg/day)	2570 (2458–2682)	2787 (2677–2897)			
Adjusted mean sodium intake (mg/day)	2655	2512	0.024	0.0144	.0975
Age					
30–49 years (n)	244	2761			
Mean sodium intake (mg/day)	3676 (3001–4351)	3290 (3147–3433)			
Adjusted mean sodium intake (mg/day)	3258	2911	0.049	0.0279	.0815
50–69 years (n)	1041	2404			
Mean sodium intake (mg/day)	3064 (2910–3219)	3052 (2931–3172)			
Adjusted mean sodium intake (mg/day)	2799	2612	0.03	0.0124	.0176
70+ years (n)	1170	1247			
Mean sodium intake (mg/day)	2451 (2338–2563)	2666 (2500–2832)			
Adjusted mean sodium intake (mg/day)	2415	2466	−0.009	0.0117	.4413
Diabetes					
Yes (n)	464	322			
Mean sodium intake (mg/day)	2767 (2541–2992)	2915 (2644–3185)			
Adjusted mean sodium intake (mg/day)	2449	2500	−0.009	0.0193	.6326
No (n)	1989	6090			
Mean sodium intake (mg/day)	2987 (2827–3147)	3185 (3085–3286)			
Adjusted mean sodium intake (mg/day)	2805	2636	0.027	0.0102	.0071

Data source: Canadian Community Health Survey, Cycle 2.2, Nutrition (2004).[14]
Abbreviations: CI, confidence interval; *p*, statistical significance.
Adjusted mean: estimated marginal mean using multivariate linear regression.

TABLE 3
Mean sodium intake (mg/day), crude and adjusted by multivariate linear regression among people with and without hypertension (aged 30 and older) for men and women, by age group.

	Hypertensive (95% CI)	Non-hypertensive (95% CI)	β coefficient	Standard error	*p*-value
Male					
Age 30 to 49 (n)	120	1282			
Mean sodium intake (mg/day)	4223 (3250–5195)	3699 (3485–3913)			
Adjusted mean sodium intake (mg/day)	3855	3250	0.074	0.0335	.0265
Age 50 to 69 (n)	402	1038			
Mean sodium intake (mg/day)	3384 (3121–3647)	3505 (3282–3727)			
Adjusted mean sodium intake (mg/day)	2844	2767	0.012	0.0169	.4834
Age 70+ (n)	356	492			
Mean sodium intake (mg/day)	2716 (2516–2916)	2922 (2733–3111)			
Adjusted mean sodium intake (mg/day)	2729	2716	0.002	0.018	.924
Female					
Age 30 to 49 (n)	124	1479			
Mean sodium intake (mg/day)	2810 (2338–3281)	2886 (2729–3043)			
Adjusted mean sodium intake (mg/day)	2965	2723	0.037	0.0509	.4646
Age 50 to 69 (n)	639	1366			
Mean sodium intake (mg/day)	2753 (2585–2920)	2694 (2531–2857)			
Adjusted mean sodium intake (mg/day)	2698	2410	0.049	0.0186	.0083
Age 70+ (n)	814	755			
Mean sodium intake (mg/day)	2256 (2151–2361)	2477 (2238–2716)			
Adjusted mean sodium intake (mg/day)	2143	2218	−0.015	0.014	.2695

Data source: Canadian Community Health Survey, Cycle 2.2, Nutrition (2004).[14]

Abbreviations: CI, confidence interval; n, sub-sample size; *p*, statistical significance.

Adjusted mean: estimated marginal mean using multivariate linear regression.

The average sodium intake for those with hypertension was then compared to those without hypertension, after adjusting for the differences in total energy intake and other confounding variables. Adjusted mean sodium intakes are significantly higher for people with hypertension than those without hypertension (p = .01) (Table 2). After adjusting for potential confounders, results also indicate that men with hypertension report a significantly higher average sodium intake than men without (p = .04), and that, while women with hypertension also report a higher average sodium intake than those without, the difference is not statistically significant. However, men and women aged 50 to 69 years with hypertension have a significantly higher mean sodium intake, compared to those of the same age without hypertension (p = .02). A similar difference between those with and without hypertension is suggested for those aged 30 to 49, but this is not statistically significant (p = .08). Among those 70 years and over, however, there is no difference in average sodium intake between those with and without hypertension.

For those without diabetes, sodium intake is considerably higher among those with hypertension compared to those without hypertension (p = .007) (Table2). However, among those with diabetes, average sodium intake is lower, though there is no statistically significant difference in average sodium intake between those with and without hypertension (Table 2).

Finally, we explored possible interactions between age groups and hypertension status for men and women separately (Table 3). After adjusting for potential confounders, only young men aged 30 to 49 with hypertension have significantly higher sodium intake than men of the same age without hypertension (p = .03). For women, only those age 50 to 69 with hypertension have significantly higher average sodium intake compared to women the same age without hypertension (p = .008).

Discussion

The risk of developing hypertension can be attributed to a number of component causes, such as age, family history, race/ethnicity, sodium intake, BMI, alcohol consumption, physical activity and diet.[18] Epidemiological studies have also consistently demonstrated the association between dietary sodium intake levels and the development of hypertension.[4-6] While adequate sodium is needed for the human body to regulate fluids and blood pressure and to keep muscles and nerves running smoothly, a healthy individual may need as little as 230 mg of sodium per day to maintain their sodium balance.[19] Hypertension is predominantly seen in developed countries where sodium is widely added to processed and restaurant food; people living in remote and isolated societies with habitually low sodium intake typically demonstrate little hypertension and little or no increase in blood pressure with aging.[20] In addition to hypertension, over-consumption of sodium is also associated with stomach cancer, left ventricle hypertrophy, obesity, and possibly with osteoporosis.[21-25]

As in previous reports summarizing CCHS 2.2, Nutrition (2004), our results show that Canadian adults 30 years and over are consuming levels of sodium above the UL. Our findings further demonstrate that average sodium intake is high in Canadian adults both with and without hypertension, with averages more than double the level considered adequate (i.e. the AI) and considerably higher than the UL. Those with diagnosed hypertension in Canada are clearly not reaching sodium reduction goals set for this sub-population by CHEP.

As a modifiable lifestyle risk factor, reducing dietary sodium is recommended in clinical guidelines for healthy people, to prevent hypertension, and for those already diagnosed with hypertension, to treat hypertension prior to any pharmaceutical interventions.[10] Canadian adults diagnosed with hypertension report adding sodium at the table and during cooking significantly less often than people without hypertension,[12] which suggests that some proportion of the population with hypertension are recommended to reduce their sodium reduction and take action to do so. However, given the cross-sectional nature of the data in our study, we were unable to determine whether persons with hypertension reduced their sodium intake and by how much. However, reducing sodium intake at the table and during cooking may not be particularly effective since, as mentioned earlier, the main source of sodium in the Canadian diet comes from processed and restaurant foods.

Our study shows that, after adjusting for potential confounders, adult Canadians with known hypertension consume higher levels of sodium than those without hypertension. Subgroup analyses further reveal varying degrees of difference in sodium intake between people with hypertension and without by gender and age. Our results identify young men (aged 30 to 49) with hypertension and mid- to old-age women (aged 50 to 69) with hypertension to have higher average sodium intake compared to their counterparts without hypertension. Our study also shows that older Canadians (aged 70 and over) with hypertension consume the same levels of sodium as those without. Although a survival effect may be playing a role in the result for the elderly, other studies report that urinary sodium reduction appears to increase with age, suggesting older individuals may generally be more health conscious and amenable to reducing their sodium use compared to younger individuals.[13,26,27] A prospective study in Finland found no significant reduction in salt intake among those with hypertension when compared to the group without hypertension after a 3-year study period, [28] suggesting that reducing sodium intake is challenging. Our results suggest that age and gender may be important factors influencing compliance with low-salt diets among people with hypertension, and that programs should be designed to reach those particularly resistant to change.

A notable finding from our study, however, was that people diagnosed with both diabetes and hypertension show no difference in adjusted average sodium intake from those with diagnosed diabetics without hypertension. In contrast, among people free of diabetes, those with hypertension had significantly higher average sodium intake compared to those without hypertension. These results are particularly interesting, given that Canadian clinical guidelines

for diabetes management recommend that elevated blood pressure be aggressively treated to achieve a target blood pressure control of less than 130/80 mmHg and that lifestyle changes be introduced that include limiting sodium intake.[29] These results suggest that sodium reduction, though challenging, may be achievable among high-risk individuals.

This study has a number of limitations. First, it is based on cross-sectional survey data which do not allow for direct assessment of lifestyle changes over time. Although we were unable to determine by how much people with hypertension reduce their sodium consumption, it is unlikely that people increase their intake after learning they have hypertension. Although the cross-sectional nature of these data does not allow us to explore the etiologic relationship of sodium intake with hypertension, we can compare current intake levels of sodium based on hypertension status reported by survey respondents. Second, information on individuals' diagnosis of hypertension, sodium consumption and other lifestyle factors was based on 24-hour dietary recall and self-reported physician diagnoses, which are subject to recall bias and misclassification. Direct measurement of all the parameters would have been optimal but also costly. Further, under-reporting of food intake is more extreme among those who are obese, compared to normal weight individuals. A higher percentage of those diagnosed with hypertension, compared to those without hypertension, were obese (41.0% vs. 22.5%, respectively). Consequently, our estimates of sodium intake in those with hypertension may be particularly conservative. Other limitations relate to undiagnosed hypertension, which is estimated to account for one-fifth of the hypertension population in Canada.[30] The misclassification of those with undiagnosed hypertension may have attenuated the difference in average sodium intake observed between groups split by hypertension status in our study. Moreover, respondents with other chronic conditions beyond hypertension and diabetes (e.g. heart and kidney disease) also require restricted sodium intake but could not be examined separately due to the limited sample size.

As our population ages, the prevalence of hypertension is expected to rise, further increasing the need for public health efforts to address it. Because most of the modifiable risk factors for hypertension pertain to western lifestyle characteristics, public health campaigns and clinical practice should emphasize healthy lifestyle changes, such as attaining and maintaining a healthy weight, reducing sodium intake, limiting alcohol consumption and increased physical activity. In Canada, steps are being taken to reduce dietary sodium intake in the general population. In 2007, the federal government established a multi-stakeholder working group to oversee the development and implementation of a comprehensive sodium reduction strategy.[31] Recommendations of this Sodium Working Group were released in July 2010 with specific recommendations in four areas, including voluntary reduction of sodium levels in the food supply; increased awareness and education about sodium, its adverse health effects and the ways to reduce its consumption; support for research to facilitate reformulation of processed foods; and the comprehensive monitoring of sodium intake in Canada and overall evaluation of the sodium reduction strategy itself.[32] In addition to public health efforts, health care professionals should emphasize the importance of lifestyle changes to prevent and manage hypertension, including the need for patients to achieve sodium reduction targets in accordance with Canadian clinical guidelines. Finally, it is also important to emphasize that although our study focussed on the sodium intake of those with hypertension, it is the quality of one's overall diet and the quantity of food consumed that determines sodium intake levels. Since roughly 70% to 80% of daily intake of sodium comes from processed foods and restaurant foods in most of the developed world, a population approach must be taken. Successful population reduction of sodium experienced in some countries suggests that an integrated, systematic approach involving cooperation among the government, the food industry, physicians and the general public will be required to achieve effective and long lasting dietary behaviour changes.[33-36]

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