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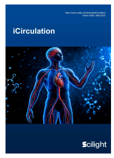

Article

Effect of Urinary Sodium-to-Potassium Ratio Monitored Intensive Salt Reduction Intervention in Community Hypertensive Patients: Cluster Randomized Controlled Trial

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Abstract: Background: To evaluate the effects of Urinary Sodium-to-Potassium Ratio Monitored Intensive Salt Reduction Intervention for Community Hypertensive Patients. Methods: This cluster randomized controlled trial was carried out between August 2023 and August 2024 in Yishui County, Shandong Province. All participants were asked to complete the blood and urine sample collection, anthropometric measurement, questionnaires at the baseline and one-year post-intervention survey, with dietary surveys conducted in a subset of participants. A total of 485 hypertensive patients aged 35 to 69 years from 15 villages were recruited at the baseline and randomly allocated in a 1:1:1 ratio to the control group, low-intensity intervention group, or high-intensity intervention group. The control group received management according to the Basic Public Health Service. The low-intensity intervention group received blood pressure monitoring, salt-restriction spoons, and health education. The high-intensity intervention group additionally received self-monitoring of salt intake and health lectures. Final survey was conducted after one year. Results: A total of 471 participants completed follow-up assessments. Compared with the control group, adjusted mixed linear model analysis showed that the systolic blood pressure decreased by 8.45 mmHg (95% confidence interval −13.57 to −3.33) in the low-intensity intervention group and 12.32 mmHg (−17.40 to −7.23) in the high-intensity intervention group. The effects of the high-intensity intervention were more pronounced, with salt intake decreasing by 2.98 g/d (−4.56 to −1.41) and spot urinary sodium-to-potassium ratio decreasing by 1.16 (−1.93 to −0.38). The knowledge and behaviors in intervention groups improved significantly. The intervention effect interacted with baseline hypertension grade (p for interaction = 0.017), with high-intensity intervention demonstrating greater blood pressure reductions in patients with grade 2 or 3 hypertension. Conclusions: The urinary sodium-to-potassium ratio monitored intensive salt reduction intervention was effective in lowering salt intake and blood pressure. Future efforts could integrate intensity salt reduction interventions and urinary sodium-to-potassium ratio monitoring into the Basic Public Health Service to improve health outcomes in hypertensive patients.

Keywords: community hypertension management; Intensive salt reduction intervention; urine sodium-to-potassium ratio

1. Introduction

Excessive salt intake increases the risk of cardiovascular and cerebrovascular diseases [1–3]. Among all risk factors contributing to disability-adjusted life years from cardiovascular diseases, dietary risk ranks second, accounting for 32.3% [4]. In China, the cardiovascular disease mortality rate attributable to high sodium intake reaches 40.91 per 100,000 population [5]. Western countries such as the United Kingdom [6], Australia [7], and the United States [8], have reduced salt intake by decreasing sodium content in processed foods. In China, sodium intake primarily comes from home cooking. Consequently, China has implemented multiple salt reduction initiatives, including low-sodium salt substitutes [9], salt-restriction spoons [10], and comprehensive interventions [11,12], which have effectively reduced salt intake.

Studies have shown a linear association between blood pressure levels and increased urinary sodium excretion and decreased urinary potassium excretion, the trend observed in both 24-h urine [13] and spot urine estimations [14]. The urinary sodium-to-potassium ratio demonstrates a stronger association with blood pressure than urinary sodium alone, with each unit increase in the sodium-to-potassium ratio associated with greater changes in systolic blood pressure (4.39 mmHg vs. 1.40 mmHg) and diastolic blood pressure (1.67 mmHg vs. 0.43 mmHg) [14]. The urinary sodium-to-potassium ratio is a better predictor of blood pressure thresholds [15] and is positively correlated with salt sensitivity of blood pressure [16]. Twenty-four-hour urine collection is not suitable for large-scale studies due to its cumbersome procedures. In recent years, spot urine specimens have gained attention as alternative indicators. Studies have demonstrated that spot urinary sodium-to-potassium ratio can effectively estimate population-level sodium-to-potassium ratios [17], and multiple measurements of this ratio are strongly associated with blood pressure [18].

In China, salt reduction management primarily relies on the Basic Public Health Service (BPHS), which incorporates salt reduction health education and follow-up assessments of salt intake for registered hypertensive patients. The BPHS has increased blood pressure control rates by 13.99% [19], and reduced uncontrolled hypertension by 30% [20]. However, Shandong Province, characterized by a high-salt diet, has residents with salt intake far exceeding the recommended 5 g/d, contributing to 0.58 years reduction in life expectancy [21]. There is an urgent need to explore more effective salt reduction models. Current salt reduction management within the BPHS faces two major challenges. First, regarding effect evaluation, the lack of tools to assess salt intake makes it difficult to evaluate the actual benefits of salt reduction in hypertension management. Based on evidence regarding urinary sodium-to-potassium ratio, this indicator could be introduced to evaluate salt reduction effects and sodium-potassium balance in hypertensive patients. Second, regarding intervention strategies, the BPHS currently employs universal health education with uniform intensity, lacking a systematic salt reduction model. Therefore, there is a need to develop personalized, stratified intensive intervention programs to improve intervention precision.

Therefore, we conducted this study on intensive salt reduction interventions monitored by urinary sodium-to-potassium ratio among community hypertensive patients. Participants received different intensities of salt reduction interventions, and changes in their spot urinary sodium-to-potassium ratios were evaluated. To evaluate the effectiveness of implementing intensity-stratified salt reduction interventions in salt reduction management.

2. Materials and Methods

2.1. Study Design

This cluster randomized controlled trial was conducted in Yishui County, Shandong Province. This region is a high-salt diet area, with residents consuming and producing substantial amounts of pickled, resulting in high salt intake. These conditions provided a realistic setting for implementing salt reduction interventions.

Fifteen villages were randomly selected from Yishui County and randomly assigned to the control group, low-intensity intervention group, or high-intensity intervention group. Thirty-three eligible hypertensive patients were selected from each village for inclusion in the study. Baseline surveys were conducted in August 2023, followed by a one-year intervention period. Final assessments were conducted in August 2024. This study was approved by the Ethics Committee of the Shandong Center for Disease Control and Prevention (SDJK-2023-021-01). All participants signed written informed consent forms and they could withdraw from the study at any time.

2.2. Study Participants

Hypertensive patients aged 35−69 years who were managed by the Basic Public Health Service and had been local residents for over 6 months were eligible for inclusion in the study and outcome evaluation.

2.3. Sample Size Calculation

The sample size calculation was based on a mean systolic blood pressure of 142.3 mmHg among self-reported hypertensive patients in Shandong Province in 2019, with an intra-cluster correlation coefficient of 0.03. Based on this, we estimated that a sample size of 450 participants could provide a power of 80% (with a two-sided α of 0.05) to detect a difference in systolic blood pressure ≥5 mmHg between groups. We took a 10% dropout rate of participants into account. We ultimately enrolled 495 participants for outcome evaluation.

2.4. Randomization and Blinding

The 15 villages were randomized 1:1:1 to the control group, low-intensity intervention group, or high-intensity intervention group using a computer-generated randomization sequence. Randomization took place after the baseline survey. The local participants and investigators were unaware of the assignment until the intervention began.

2.5. Intervention Measures

The control group received salt reduction management according to the Basic Public Health Service. No additional interventions were provided to this group.

The low-intensity intervention group received interventions included blood pressure monitoring, salt reduction tools, establishment of a supportive environment, and health education. Village clinics measured participants' blood pressure every two weeks, assessed blood pressure control status and provided recommendations based on the trend of blood pressure changes to encourage participants to strengthen or maintain salt reduction behaviors. We provided salt-restriction spoons and instructions for use to participants and their household cooks. A salt reduction environment was created by posting posters and promotional images, and village broadcast systems were utilized for publicity. We distributed salt reduction brochures and provided participants and their household cooks with education on salt reduction knowledge and guidance on cooking techniques for salt reduction once a month. Based on the urinary sodium-to-potassium ratio measured during follow-up, we explained the meaning of the ratio to participants in the intervention groups and provided tailored recommendations according to its changing trend.

The high-intensity intervention group received additional interventions provided to the low-intensity group, including self-monitoring of salt intake, gradual salt reduction goals, and health lectures. Participants completed a 3-day self-monitoring record of salt intake monthly using salt-restriction spoons. For participants with salt intake exceeding 5g/d, we developed staged salt reduction goals and guided them in gradually reducing salt intake. Additionally, salt reduction health lectures were organized every two months, covering topics including salt and diseases, dietary sodium sources, cooking techniques, salt reduction misconceptions, low-sodium salt substitutes, and interpretation of food nutrition labels, with opportunities for on-site questions and answers.

To ensure consistency in the implementation of the intervention across different villages and village doctors, the following standardization measures were taken. Before the study began, we developed and uniformly distributed salt reduction brochures, 2 g salt-restriction spoons, blood pressure monitoring record forms, self-monitoring record forms for salt intake, and health lecture slides. All village doctors responsible for delivering the interventions received standardized training covering the overall protocol, proper use of each tool, standard blood pressure measurement procedures, and key points of health education, ensuring that each doctor fully understood the intervention protocol. During the study period, the research team collected routine monitoring records submitted by village doctors on a monthly basis, reviewed the implementation status of each intervention, and promptly communicated with village doctors to correct any deviations, thereby ensuring that the intervention was delivered uniformly according to the protocol.

2.6. Data Collection

All participants were required to complete questionnaire surveys, physical measurements, and blood and urine sample collection at baseline and at the final assessment. Dietary surveys were conducted on a subset of participants. During the 3-month follow-up visits, blood pressure and urine samples were collected from all participants.

Information on salt reduction knowledge, attitude and practice (KAP), and lifestyle factors (e.g., smoking, and alcohol drinking) were collected in face-to-face questionnaires administered by trained researchers.

The BP was measured three times by trained researchers using a validated automatic blood pressure monitor (OMRON: HBP-1300) following the standard protocol. The mean of the last two BP measurements was included in the analysis. All blood pressure measurements were independently obtained by trained research staff. Height, weight, waist circumference, and hip circumference were measured by research staff using standardized, calibrated instruments.

Trained research staff instructed participants to collect 5 mL random spot urine specimens on the survey day. Urine samples were analyzed for sodium (Mindray: BS-2800M), potassium (Mindray: BS-2800M), creatinine (Beckman: AU5800), and microalbumin concentrations (Mindray: BS-2800M). During follow-up, spot urine specimens were collected from participants to calculate the urinary sodium-to-potassium ratio. Based on the dynamic changes in this ratio, the effectiveness of salt reduction was assessed, and corresponding health education on sodium reduction and potassium supplementation was provided. Fasting blood samples were collected to measure fasting blood glucose (Beckman: AU5800) and lipid profile (Beckman: AU5800). All laboratory tests included internal quality control and blinded external quality control.

Twenty percent of participants were randomly selected from each village. Dietary surveys using the weighing method were conducted to measure consumption of salt and condiments over three consecutive days, from which participants' salt intake was calculated.

2.7. Definition of Indicators

Smokers were defined as participants answering "yes" to "Do you use tobacco daily?" Alcohol drinkers were defined as participants answering "yes" to "Do you regularly consume alcoholic beverages?" Physical activity level was categorized as low or moderate-to-high according to the Global Physical Activity Questionnaire (GPAQ) guidelines. Diabetes was defined as having a history of diabetes or fasting plasma glucose (FPG) ≥ 7.0 mmol/L. Dyslipidemia was defined as having a history of dyslipidemia, or total cholesterol (TC) ≥ 6.2 mmol/L, or triglycerides (TG) ≥ 2.3 mmol/L, or low-density lipoprotein cholesterol (LDL-C) ≥ 4.1 mmol/L, or high-density lipoprotein cholesterol (HDL-C) < 1.0 mmol/L. Medication status was categorized as taking or not taking antihypertensive medication. Perceived salt taste preference was categorized as light, moderate, or salty (based on participants' responses to "How would you describe your salt taste preference?" as "light", "moderate", or "salty"). The history of cardiovascular diseases was defined as having one or more of angina, myocardial infarction, or stroke.

2.8. Outcomes

The primary outcomes included differences in changes in urinary sodium-to-potassium ratio, systolic blood pressure, diastolic blood pressure, and salt intake from the baseline to the end of the trial between the control group, low-intensity intervention group, and high-intensity intervention group. Secondary outcomes were the differences in the changes from KAPs on salt reduction from the baseline to the end of the trial between the control group, low-intensity intervention group, and high-intensity intervention group.

All outcome measures were objectively assessed by trained research staff using standardized protocols.

2.9. Statistical Analysis

The effect of intensive salt reduction intervention on the outcomes using a linear mixed model (individual-level data were nested at the village level) combined with difference-in-differences methods. The independent variables included group (control group, low-intensity intervention group, and high-intensity intervention group), time (baseline and final assessment), and time × group interaction. The group × time interaction term represented the net intervention effect from baseline to the final assessment. Models adjusted for potential confounding variables, including age (years), body mass index (kg/m^2), sex (male = 1, female = 2), education level (junior high school and below = 1, high school and above = 2), smoking (non-smoker = 1, smoker = 2), alcohol consumption (non-drinker = 1, drinker = 2), diabetes (non-diabetic = 1, diabetic = 2), dyslipidemia (no dyslipidemia = 1, dyslipidemia = 2), medication status (not taking medication = 1, taking medication = 2), history of cardiovascular diseases (no history of myocardial infarction, stroke, or angina pectoris = 1, presence of any of the above = 2), and perceived salt taste preference (light = 1, moderate = 2, salty = 3). Subgroup analyses were conducted to examine intervention effects and interactions across different age groups, sexes, blood pressure control status, and hypertension grades.

We used R (version 4.3.1) for data analysis. Continuous variables were described as means and standard deviations (SDs) and presented as mean estimates and 95% confidence intervals (CI) in the inferential analyses. Categorical variables were described as the frequencies and percentages, odds ratios (ORs) and 95% CI in the inferential analyses. The Analysis of variance (ANOVA) and chi-square tests were used to assess between-group differences. All analyses were two-sided, and $p < 0.05$ was considered significant.

3. Results

3.1. Baseline Characteristics of Participants

A total of 495 hypertensive patients were recruited in 15 villages. 10 respondents were excluded due to refusal to participate. 485 participants completed a baseline survey. After randomization, 159 participants were allocated to the control group, 162 to the low-intensity intervention group, and 164 to the high-intensity intervention group. During the trial, 14 participants were lost to follow-up due to death, work-related inconvenience, or refusal to continue, resulting in a total of 471 participants who completed the final assessment (Figure 1).

Table 1 shows the baseline characteristics of participants in the control group, low-intensity intervention group, and high-intensity intervention group. The mean age of the 485 participants was 60.06 years, and 37.7% of them were male. The mean BMI was 26.59 kg/m^2, 30.9% had diabetes, 64.3% had dyslipidemia, and 28.0% self-reported a salty taste preference. The three groups were well balanced in most parameters except age and physical activity. The high-intensity intervention group had the highest mean age, and the low-intensity intervention group had the lowest proportion of moderate-to-high physical activity. Baseline characteristics of the subset of participants who underwent dietary surveys are presented in Table S1.

Table 1. Participants' baseline characteristics.

Characteristics	Control (n = 159)	Low-Intensity Intervention (n = 162)	High-Intensity Intervention (n = 164)	*p*-Value
Age (year), Mean (SD)	58.94 (6.76)	60.36 (7.60)	60.86 (6.89)	0.044
BMI (kg/m^2), Mean (SD)	26.97 (4.17)	26.22 (3.65)	26.59 (3.38)	0.206
Men, n (%)	63 (39.6)	68 (42.0)	52 (31.7)	0.134
Education status, n (%)				
Primary school and less	107 (67.3)	112 (69.1)	125 (76.2)	0.435
Junior high school	37 (23.3)	36 (22.2)	26 (15.9)	
High school and above	15 (9.4)	14 (8.6)	13 (7.9)	
Smokers, n (%)	27 (17.0)	34 (21.0)	19 (11.6)	0.072
Alcohol drinkers, n (%)	29 (18.2)	29 (17.9)	26 (15.9)	0.828
Moderate and above Physical activity, n (%)	68 (42.8)	39 (24.1)	49 (29.9)	0.001
Diabetes, n (%)	150 (30.9)	57 (35.8)	48 (29.6)	0.239
Dyslipidemia, n (%)	312 (64.3)	105 (66.0)	99 (61.1)	0.577
Salt taste preference, n (%)				0.911
Low	138 (28.5)	44 (27.7)	50 (30.9)	
Moderate	211 (43.5)	70 (44.0)	70 (43.2)	
High	136 (28.0)	45 (28.3)	42 (25.9)	
Take hypertension medication, n (%)	140 (88.1)	148 (91.4)	148 (90.2)	0.607
History of cardiovascular diseases, n (%)	55 (34.6)	42 (25.9)	45 (27.4)	0.191

3.2. Dynamic Changes in Blood Pressure Levels and Spot Urinary Sodium-to-Potassium Ratio

Figure 2 shows the trends in systolic blood pressure (A), diastolic blood pressure (B), and spot urinary sodium-to-potassium ratio (C) during the trial. Systolic and diastolic blood pressure showed increasing trends in the control group, while both intervention groups showed decreasing trends after a transient increase at the November follow-up, with greater reductions in the high-intensity intervention group. The trend in urinary sodium-to-potassium ratio was similar to that of blood pressure, remaining stable in the control group with the largest decrease in the high-intensity intervention group.

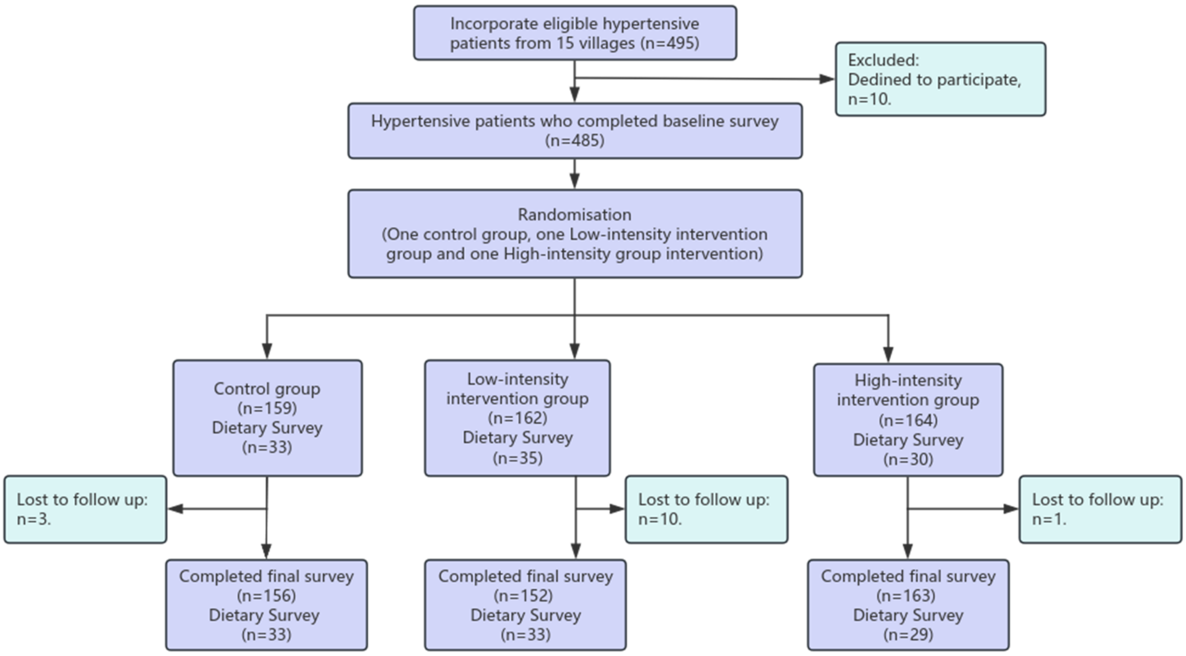

Figure 1. Flowchart of participants in the baseline and follow-up surveys.

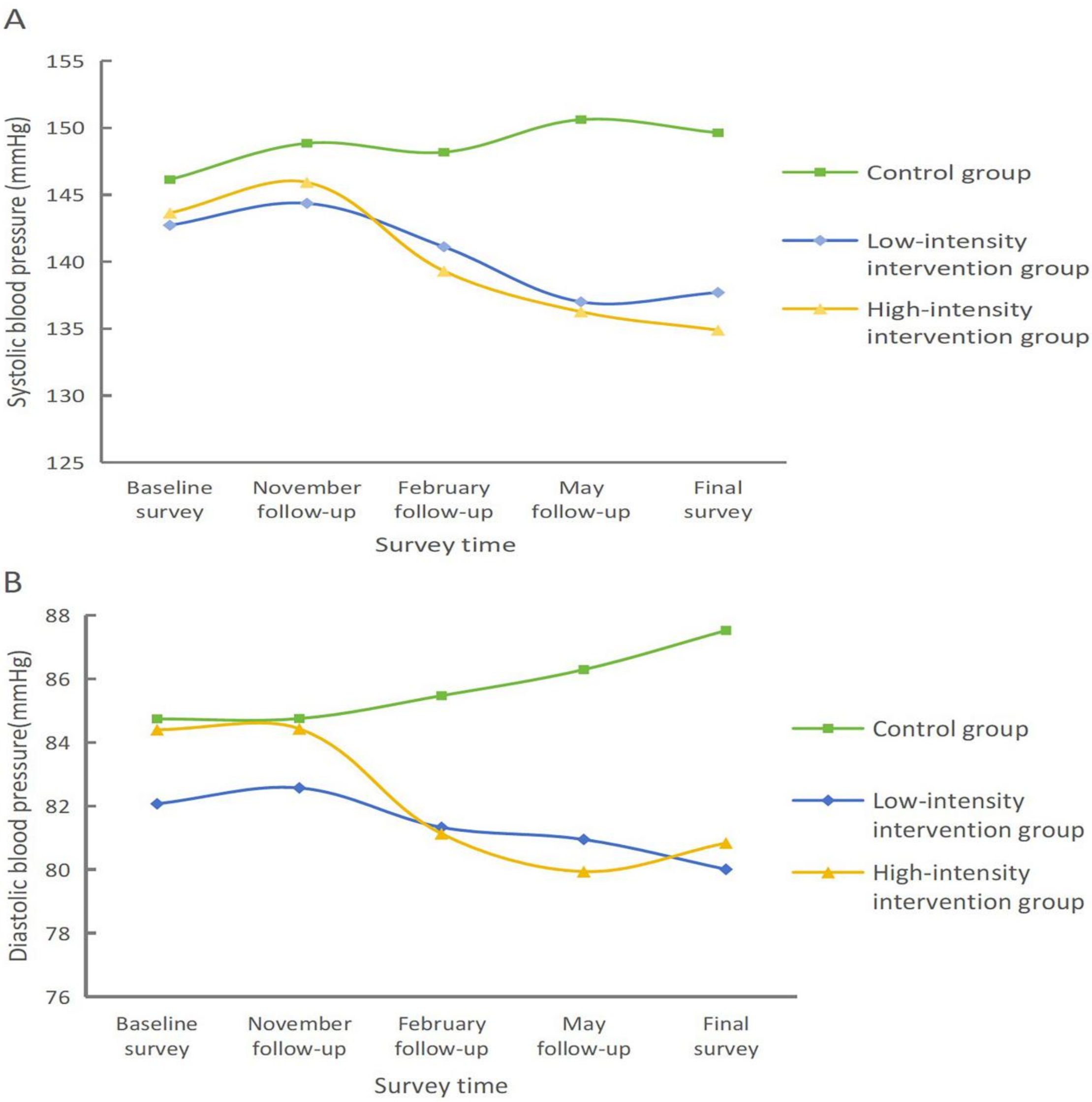

Figure 2. *Cont.*

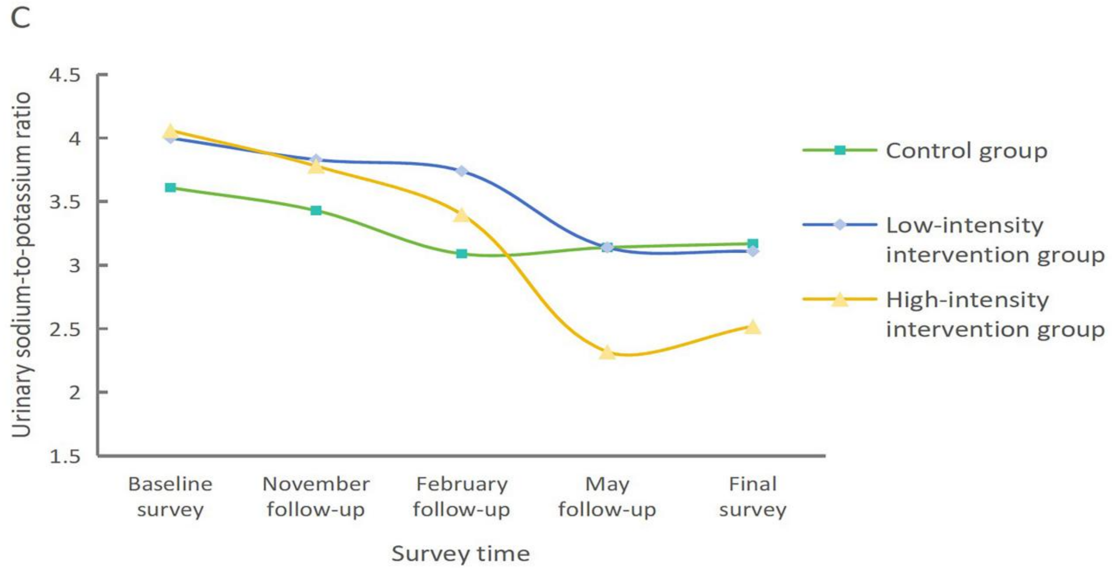

Figure 2. Dynamic changes in blood pressure levels and the spot urinary sodium-to-potassium ratio. (**A**). The dynamic changes in systolic blood pressure. (**B**). The dynamic changes in diastolic blood pressure. (**C**). The dynamic changes in spot urinary sodium-to-potassium ratio.

3.3. Intervention Effects on Salt Intake, Spot Urinary Sodium-to-Potassium Ratio, and Blood Pressure Levels

Tables 2 and S2 show the covariates-adjusted mixed linear model results of the spot urinary sodium-to-potassium ratio, blood pressure levels, and salt intake. After the intervention, no significant changes were observed in the urinary sodium-to-potassium ratio in the control group and low-intensity intervention group ($p > 0.05$), while the high-intensity intervention group showed a decrease of 1.16 (95% confidence interval −1.93 to −0.38). Regarding salt intake, the low-intensity intervention group decreased by 2.78 g/d (−4.30 to −1.26), and the high-intensity intervention group decreased by 2.98 g/d (−4.56 to −1.41), slightly higher than that of the low-intensity group. Blood pressure also decreased in two intervention groups, with greater decreases in the high-intensity intervention group. The intervention effect for systolic blood pressure was −8.45 mmHg (−13.57 to −3.33) in the low-intensity group and −12.32 mmHg (−17.40 to −7.23) in the high-intensity group. Diastolic blood pressure exhibited the same trend as systolic blood pressure.

Tables 3 and S3 show the subgroup analysis results. No significant differences in the effect on blood pressure, salt intake, or urinary sodium-to-potassium ratio between age groups and genders (p for interaction > 0.05). A significant interaction was observed across participants with different hypertension grades (p for interaction = 0.017), patients with grade 2 or higher hypertension receiving high-intensity intervention showing greater reductions in blood pressure. Regarding salt intake reduction, participants with controlled blood pressure showed greater salt reduction effect in high-intensity intervention group (p for interaction = 0.038).

3.4. Intervention Effects on Salt Reduction Knowledge, Attitudes, and Behaviors

Table 4 shows the results for the knowledge, attitude, and behaviors of salt reduction in the baseline and at the 12-month survey. Compared with the control group, there is a significant intervention effect on increasing the proportion of participants aware of salt-restriction spoons in the high-intensity intervention group (odds ratio 31.55, 95% confidence interval 12.69 to 78.45). The low-intensity intervention group also showed increased awareness of low-sodium salt substitutes (4.69, 1.84 to 11.95) and salt-restriction spoons (9.57, 4.43 to 20.65). No significant difference was seen in the proportion of participants willing to choose a low-salt diet ($p > 0.05$). After the intervention, the frequency of reducing salt in home cooking and decreasing consumption of pickled increased in both intervention groups. Furthermore, improvements in the use of low-sodium salt substitutes (2.71, 1.25 to 5.90) and correct use of salt-restriction spoons (4.26, 1.17 to 15.45) were significant only in the high-intensity intervention group.

Table 2. Results for Salt intake, sodium-to-potassium ratio, and blood pressure from multivariable-adjusted models.

	Control			**Low-intensity intervention**					**High-Intensity Intervention**				
	Baseline Mean (SD) (n = 159)	**12-Month Mean (SD) (n = 156)**	**Change from Baseline (*β*, 95% CI)**	**Baseline Mean (SD) (n = 162)**	**12-Month Mean (SD) (n = 152)**	**Change from Baseline (*β*, 95% CI)**	**Adjust Difference * (*β*, 95% CI)**	***p*-Value**	**Baseline Mean (SD) (n = 164)**	**12-Month Mean (SD) (n = 163)**	**Change from Baseline (*β*, 95% CI)**	**Adjust Difference * (*β*, 95% CI)**	***p*-Value**
sodium-to-potassium ratio	3.61 (2.61)	3.17 (2.08)	−0.45 (−1.00,0.11)	4.00 (3.35)	3.11 (2.41)	−0.92 (−1.48,−0.36)	−0.47 (−1.25, 0.31)	0.240	4.06 (3.02)	2.52 (1.36)	−1.60 (−2.15,−1.05)	−1.16 (−1.93, −0.38)	0.004
Systolic blood pressure (mmHg)	146.14 (20.49)	149.64 (17.95)	3.49 (−0.16,7.14)	142.73 (18.19)	137.71 (14.54)	−4.96 (−8.62,−1.30)	−8.45 (−13.57, −3.33)	0.001	143.65 (17.34)	134.90 (11.76)	−8.83 (−12.43,−5.22)	−12.32 (−17.40, −7.23)	<0.001
Diastolic blood pressure (mmHg)	84.74 (12.55)	87.52 (10.41)	2.67 (0.62,4.72)	82.07 (11.08)	80.01 (8.37)	−2.00 (−4.06,0.06)	−4.67 (−7.55, −1.79)	0.002	84.40 (10.94)	80.84 (6.70)	−3.51 (−5.54,−1.49)	−6.18 (−9.04, −3.32)	<0.001

Model-based change for Salt intake, sodium-to-potassium ratio, and blood pressure were adjusted for age, BMI, sex, education level, physical activity, drink status, smoke status, diabetes, dyslipidemia, Salt taste preference, take hypertension medication and history of cardiovascular diseases. * Results were obtained from mixed linear model, the "Adjusted Difference" is the estimate for the group × time interaction term, reflecting the net effect of the intervention from baseline to the final assessment.

Table 3. Results for sodium-to-potassium ratio and blood pressure from multivariable-adjusted models by subgroup.

	Systolic Blood Pressure		**Diastolic Blood Pressure**		**Sodium-to-Potassium Ratio**	
	Intervention Effect * (Low-Intensity Intervention vs. Control, *β*, 95% CI)	**Intervention Effect * (High-Intensity Intervention vs. Control, *β*, 95% CI)**	**Intervention Effect * (Low-Intensity Intervention vs. Control, *β*, 95% CI)**	**Intervention Effect * (High-Intensity Intervention vs. Control, *β*, 95% CI)**	**Intervention Effect * (Low-Intensity Intervention vs. Control, *β*, 95% CI)**	**Intervention Effect * (High-Intensity Intervention vs. Control, *β*, 95% CI)**
Age (years)						
<60	−7.55(−15.20, 0.11)	−13.22 (−21.02, −5.42)	−6.09 (−10.24, −1.95)	−9.09 (−13.32, −4.86)	−0.60 (−1.69, 0.49)	−1.30 (−2.41, −0.19)
≥60	−8.78 (−15.57, −1.98)	−11.39 (−18.05, −4.74)	−3.61 (−7.45, 0.23)	−4.43 (−8.18, −0.68)	−0.22 (−1.32, 0.80)	−0.88 (−1.96, 0.20)
p for interaction	0.873	0.729	0.367	0.112	0.617	0.602
Gender						
Male	−6.82 (−14.50, 0.87)	−13.93 (−22.15, −5.71)	−4.06 (−8.70, 0.58)	−7.53 (−12.49, −2.57)	−0.16 (−1.51, 1.18)	−0.42 (−1.86, 1.01)
Female	−9.57 (−16.20, −2.93)	−11.64 (−17.97, −5.31)	−5.13 (−8.70, −1.56)	−5.74 (−9.15, −2.34)	−0.66 (−1.59, 0.27)	−1.58 (−2.47, −0.69)
p for interaction	0.604	0.667	0.772	0.545	0.599	0.109
Good blood pressure control						
No	−10.48 (−15.77, −5.20)	−16.14(−21.19, −11.10)	−7.33(−10.87, −3.80)	−8.18(−11.54, −4.83)	−0.44 (−1.49,0.61)	−1.48 (−2.48, −0.49)
Yes	−7.89 (−12.63, −3.32)	−7.80 (−12.64, −2.95)	−2.33 (−5.65,0.98)	−3.45 (−6.90,0.01)	−0.66 (−1.80,0.48)	−0.73 (−1.91,0.46)
p for interaction	0.438	0.027	0.055	0.071	0.812	0.363
The degree of hypertension						
Grade 1 hypertension	−7.78 (−12.23, −3.33)	−10.62 (−15.01, −6.23)	−4.49 (−7.30, −1.69)	−4.90 (−7.67, −2.13)	−0.80 (−1.65,0.05)	−1.04 (−1.88, −0.21)
Grade 2 and Grade 3 hypertension	−12.56 (−19.81, −5.31)	−21.59 (−28.95, −14.23)	−6.58 (−12.27, −0.90)	−12.47 (−18.24, −6.69)	0.70 (−1.06,2.47)	−1.70 (−3.50,0.10)
p for interaction	0.266	0.017	0.538	0.014	0.116	0.470

Model-based change for Salt intake, sodium-to-potassium ratio, and blood pressure were adjusted for age, BMI, sex, education level, physical activity, drink status, smoke status, diabetes, dyslipidemia, Salt taste preference, take hypertension medication and history of cardiovascular diseases. * Results were obtained from mixed effect logistic regression model, the "Intervention Effect" is the estimate for the group × time interaction term, reflecting the net effect of the intervention from baseline to the final assessment.

Table 4. Results for knowledge, attitude and behaviors of salt education from multivariable-adjusted models.

Outcomes	Control			Low-Intensity Intervention					High-Intensity Intervention				
	Baseline Mean (SD) (n = 159)	**12-Month Mean (SD) (n = 156)**	**Change from Baseline (*OR*, 95% CI)**	**Baseline Mean (SD) (n = 162)**	**12-Month Mean (SD) (n = 152)**	**Change from Baseline *OR*, 95% CI)**	**Adjust Difference * (*OR*, 95% CI)**	***p*-Value**	**Baseline Mean (SD) (n = 164)**	**12-Month Mean (SD) (n = 163)**	**Change from Baseline (*OR*, 95% CI)**	**Adjust Difference * (*OR*, 95% CI)**	***p*-Value**
Knowledge													
Having the knowledge of the recommended salt intake of 5 g/d.	34 (21.38)	38 (24.36)	1.19 (0.68,2.09)	31 (19.14)	41 (26.97)	1.65 (0.94,2.89)	1.38 (0.63,3.06)	0.428	37 (22.56)	51 (31.29)	1.73 (1.00,2.99)	1.45 (0.66,3.18)	0.354
Having heard about a low-sodium salt substitute.	25 (15.72)	33 (21.15)	1.49 (0.81,2.74)	13 (8.02)	48 (31.58)	6.99 (3.42,14.29)	4.69 (1.84,11.95)	0.001	30 (18.29)	67 (41.1)	4.20 (2.36,7.48)	2.81 (1.22,6.49)	0.015
Having heard about salt spoon.	33 (20.75)	44 (28.21)	1.52 (0.90,2.58)	41 (25.31)	124 (81.58)	14.55 (8.30,25.50)	9.57 (4.43,20.65)	<0.001	43 (26.22)	153 (93.87)	47.98 (22.82,100.90)	31.55 (12.69,78.45)	<0.001
Having the ability to identify salt content on a food label.	7 (4.4)	12 (7.69)	1.86 (0.71,4.88)	12 (7.41)	35 (23.03)	5.10 (2.33,11.17)	2.74 (0.79,9.52)	0.113	22 (13.41)	49 (30.06)	3.24 (1.78,5.92)	1.75 (0.56,5.44)	0.336
Attitude													
Willing to choose low sodium diet.	151 (94.97)	148 (94.87)	0.99 (0.36,2.76)	149 (91.98)	149 (98.03)	4.62 (1.28,16.61)	4.66 (0.90,23.02)	0.068	148 (90.24)	158 (96.93)	3.67 (1.30,10.36)	3.70 (0.86,15.93)	0.083
Practice													
Reduce the amount of salt used in home cooking.	72 (45.28)	78 (50)	1.22 (0.78,1.91)	85 (52.47)	122 (80.26)	3.86 (2.30,6.48)	3.17 (1.60,6.30)	0.001	81 (49.39)	141 (86.5)	7.21 (4.12,12.62)	5.92 (2.89,12.15)	<0.001
Use low-sodium salt substitute.	32 (20.13)	34 (21.79)	1.12 (0.64,1.95)	39 (24.07)	50 (32.89)	1.63 (0.97,2.71)	1.46 (0.68,3.11)	0.323	28 (17.07)	59 (36.2)	3.03 (1.76,5.20)	2.71 (1.25,5.90)	0.012
Correctly use salt spoon.	12 (7.55)	14 (8.97)	1.24 (0.51,3.01)	6 (3.7)	16 (10.53)	3.72 (1.33,10.45)	2.99 (0.77,11.64)	0.117	10 (6.1)	27 (16.56)	5.30 (2.07,13.56)	4.26 (1.17,15.45)	0.027
Limit the intake of pickled.	22 (13.84)	26 (16.67)	1.25 (0.67,2.32)	23 (14.2)	129 (84.87)	36.63 (19.33,69.41)	29.38 (12.05,71.67)	<0.001	33 (20.12)	134 (82.21)	19.86 (11.24,35.11)	15.94 (6.86,37.02)	<0.001

Model-based change for Salt intake, sodium-to-potassium ratio, and blood pressure were adjusted for age, BMI, sex, education level, physical activity, drink status, smoke status, diabetes, dyslipidemia, Salt taste preference, take hypertension medication and history of cardiovascular diseases. * Results were obtained from mixed effect logistic regression model, the "Adjusted Difference" is the estimate for the group × time interaction term, reflecting the net effect of the intervention from baseline to the final assessment.

4. Discussion

This study was a comprehensive salt reduction intervention study designed to reduce salt intake in rural areas. With the one-year comprehensive intervention, the findings showed that the intervention did decrease the blood pressure, salt intake, and urinary sodium-to-potassium ratio. Salt-related knowledge and behaviors improved significantly following the intervention.

In China, up to 76% of salt intake comes from home cooking [22], necessitating targeted interventions. Among previous comprehensive intervention programs, the SMASH study in Shandong Province implemented multi-setting strategies in schools, restaurants, and communities, achieving a systolic blood pressure of 130.0 mmHg among participants [11]. The SHRPP study in Zhejiang Province targeted household cooks through salt-restriction spoons and health education, resulting in a systolic blood pressure reduction of 1.3 mmHg [23]. This study implemented intensity-stratified salt reduction interventions among hypertensive patients managed by the BPHS, including blood pressure monitoring, health education, salt-restriction spoons, and salt intake monitoring. After the intervention, systolic blood pressure decreased by 8.45 mmHg and 12.32 mmHg in the low-intensity and high-intensity intervention groups; diastolic blood pressure decreased by 4.67 mmHg and 6.18 mmHg, respectively; and salt intake decreased by 2.78 g/d and 2.98 g/d, respectively. These findings are consistent with previous studies [24]. The differences in intervention effects may be attributed to intervention intensity. First, frequent blood pressure monitoring may have played a key role, which is consistent with meta-analysis findings [25]. Second, we used fragmented contact time between patients and village doctors to deliver knowledge. Studies have shown that health education for salt reduction significantly lowers blood pressure (systolic blood pressure: −8.1 mmHg; diastolic blood pressure: −4.5 mmHg) [26]. Finally, we distributed salt-restriction spoons and guided participants in monthly self-monitoring, enabling them to intuitively understand and control their salt intake. Research indicates that individuals using salt-restriction spoons have significantly lower salt intake compared to non-users [10]. The intervention effects showed an increasing trend in the high-intensity intervention group, suggesting that intensified behavioral interventions can yield greater health benefits.

Our findings showed that salt intake decreased significantly in both the low-intensity and high-intensity intervention groups, while the self-reported frequencies of daily fresh vegetable consumption and weekly fruit consumption did not change significantly from baseline to post-intervention (p > 0.05). This indicates that the urinary sodium-to-potassium ratio-monitored intensive salt reduction intervention can improve sodium-potassium balance and subsequently affect blood pressure. Moreover, the reduction in urinary sodium-to-potassium ratio was greater in the high-intensity intervention group than in the low-intensity group (1.16 vs. 0.47), which may be attributed to its more systematic health education and salt intake self-monitoring. Self-monitoring can significantly improve salt reduction behaviors. Studies have shown that salt meter monitoring can additionally reduce systolic blood pressure by 4 mmHg compared to health education alone [27], and salt self-monitoring devices have been shown to significantly lower systolic blood pressure by 4.4 mmHg [28]. In this study, we dynamically monitored spot urinary sodium-to-potassium ratio and provided recommendations. This gave participants feedback on their salt reduction effects, which may have facilitated behavioral change. Shimoyama showed that participants achieved a reduction in salt intake of 1.9 g/d through self-monitoring of urinary sodium-to-potassium ratio [29]. Therefore, monitoring changes in the urinary sodium-to-potassium ratio may be an effective approach to enhancing salt reduction effects. Future studies could consider using the urinary sodium-to-potassium ratio as a monitoring indicator, to adjust and evaluate the implementation and effectiveness of salt reduction interventions.

Public awareness of the relationship between salt and blood pressure is positively associated with healthy behaviors. In this study, participants' knowledge, attitude, and behaviours improved significantly, particularly the proportion of participants aware of low-sodium salt substitutes and salt-restriction spoons (p < 0.05). No significant improvements were observed in knowledge of the recommended daily salt intake and sodium content on nutrition labels, and the improvements were lower than those reported in intervention studies by Liu [12] and Zhang [30]. This may be because the study was conducted in an economically underdeveloped rural area, where participants were predominantly older adults with low educational levels, who may have difficulty remembering this information [31]. Behavioral change is more complex than knowledge. Given the local high-salt dietary pattern, the intervention effectively increased the proportion of participants practicing home cooking with less salt and reducing pickled (p < 0.05). Notably, a significant improvement in the correct use of salt-restriction spoons was observed only in the high-intensity intervention group, which also showed greater reductions in salt intake and blood pressure. This suggests that establishing complex behaviors requires intensive intervention. Therefore, salt reduction interventions targeting rural hypertensive patients should, in addition to health education, strengthen guidance on salt reduction behaviors and tool usage to facilitate the translation of knowledge into behavior.

Subgroup analysis showed no significant differences in intervention effects across age and sex groups, indicating that the intervention has broad applicability. An interaction between baseline hypertension grade and intervention effect was observed in the high-intensity intervention group. This may be because patients with severe hypertension have higher baseline blood pressure levels and thus greater potential for reduction. Existing evidence indicates that salt reduction interventions have greater blood pressure-lowering effects in hypertensive populations [32]. Higher baseline blood pressure is associated with larger reductions in systolic blood pressure among individuals consuming a low-sodium diet [33]. The greater benefit in salt reduction observed among participants with well-controlled baseline blood pressure may be related to their stronger health awareness and higher adherence.

This study found that low-intensity interventions, consisting of blood pressure monitoring, salt-restriction spoons, and health education, effectively improved health status in hypertensive patients, with high-intensity interventions demonstrating even greater effects. These findings provide evidence for optimizing salt reduction management models within the Basic Public Health Service (BPHS). Based on subgroup findings and evidence from urinary sodium-to-potassium ratio research, implementing salt reduction interventions in patients with grade 2 or 3 hypertension can achieve more significant effects. Therefore, in salt reduction management within the BPHS, risk stratification based on urinary sodium-to-potassium ratio and blood pressure levels may be considered. Patients with high urinary sodium-to-potassium ratio and grade 1 hypertension could be classified as low-risk, while those with low urinary sodium-to-potassium ratio or grade 2 or higher hypertension could be classified as high-risk. For low-risk populations, measures such as frequent blood pressure monitoring and guidance on salt-restriction spoon usage could be integrated into routine BPHS activities. For high-risk populations, intensive interventions should be implemented, including guidance on salt intake monitoring using salt-restriction spoons, establishment of hypertension management groups, and utilization of urinary sodium-to-potassium ratio monitoring results as a feedback tool for evaluating effects. This would facilitate the transition of salt reduction management from a universal approach to a more precise and efficient strategy.

The strengths of this study are as follows. First, we implement different intervention intensities to confirm the effectiveness of low-intensity interventions and greater benefits of high-intensity interventions, supporting stratified salt reduction strategies. Second, we incorporated urinary sodium-to-potassium ratio monitoring enabled dynamic assessment of participants' sodium-potassium balance, supporting this indicator for evaluating large-scale salt reduction effects. This study also has several limitations. First, the absence of post-intervention follow-up made it difficult to assess the long-term maintenance of salt reduction behaviors. Second, because only spot urine specimens were collected and spot urinary sodium and potassium have high intra-individual variability, we could not accurately determine the respective contributions of sodium reduction versus potassium increase to the change in the urinary sodium-to-potassium ratio. Furthermore, we did not collect detailed information on the types or dose adjustments of antihypertensive and antidiabetic medications taken by participants during the study period. Therefore, we could not accurately assess the potential impact of medication changes on the urinary sodium-to-potassium ratio. Third, the study was conducted solely in Yishui County, limiting its representativeness. Larger-scale studies in broader populations are needed to enhance generalizability.

5. Conclusions

The urinary sodium-to-potassium ratio-monitored intensive salt reduction intervention in community-dwelling hypertensive patients effectively improved participants' health status. In the future, stratified salt reduction management can be integrated into Basic Public Health Services. For low-risk populations, health education and salt-restriction spoons should be promoted; for high-risk populations, salt intake monitoring and self-management groups should be implemented. The urinary sodium-to-potassium ratio can be used to assess sodium-potassium balance, thereby comprehensively improving the cardiovascular health of hypertensive patients.

Supplementary Materials

The additional data and information can be downloaded at: https://media.sciltp.com/articles/others/2609221726581714/iCirculation-26030136-SI.pdf. Table S1: Baseline characteristics of dietary survey participants. Table S2: Results for Salt intake from multivariable-adjusted models. Table S3: Results for Salt intake from multivariable-adjusted models by subgroup.

Author Contributions

R.G.: software, writing—original draft, formal analysis; J.T.: investigation, resources; D.L.: data curation, writing—review & editing; J.R.: data curation, funding acquisition; G.Y.: investigation, writing—review & editing;

J.D.: visualization, project administration; B.Z. and X.G.: conceptualization, methodology, supervision. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Ethics Committee of the Shandong Center for Disease Control and Prevention (SDJK-2023-021-01).

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

Data are available upon request.

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Conflicts of Interest

The authors declare no conflict of interest.

Use of AI and AI-Assisted Technologies

No AI tools were utilized for this paper.

References

1. Meneton, P.; Jeunemaitre, X.; de Wardener, H.E.; et al. Links between Dietary Salt Intake, Renal Salt Handling, Blood Pressure, and Cardiovascular Diseases. *Physiol. Rev.* **2005**, *85*, 679–715. https://doi.org/10.1152/physrev.00056.2003.
2. Strazzullo, P.; D'Elia, L.; Kandala, N.-B.; et al. Salt Intake, Stroke, and Cardiovascular Disease: Meta-Analysis of Prospective Studies. *BMJ* **2009**, *339*, b4567. https://doi.org/10.1136/bmj.b4567.
3. He, F.J.; Tan, M.; Ma, Y.; et al. Salt Reduction to Prevent Hypertension and Cardiovascular Disease: JACC State-of-the-Art Review. *J. Am. Coll. Cardiol.* **2020**, *75*, 632–647. https://doi.org/10.1016/j.jacc.2019.11.055.
4. Global Burden of Cardiovascular Diseases and Risks 2023 Collaborators. Global, Regional, and National Burden of Cardiovascular Diseases and Risk Factors in 204 Countries and Territories, 1990–2023. *J. Am. Coll. Cardiol.* **2025**, *86*, 2167–2243. https://doi.org/10.1016/j.jacc.2025.08.015.
5. Chen, X.; Zhong, F.; Li, J. The Burden of Cardiovascular Disease Attributable to Dietary Risk Factors in China, 1990–2021. *Sci. Rep.* **2025**, *15*, 25641. https://doi.org/10.1038/s41598-025-11645-z.
6. Song, J.; Tan, M.; Wang, C.; et al. Salt Intake, Blood Pressure and Cardiovascular Disease Mortality in England, 2003–2018. *J. Hypertens.* **2023**, *41*, 1713–1720. https://doi.org/10.1097/HJH.0000000000003521.
7. Land, M.-A.; Wu, J.H.Y.; Selwyn, A.; et al. Effects of a Community-Based Salt Reduction Program in a Regional Australian Population. *BMC Public Health* **2016**, *16*, 388. https://doi.org/10.1186/s12889-016-3064-3.
8. Moran, A.J.; Wang, J.; Sharkey, A.L.; et al. US Food Industry Progress Toward Salt Reduction, 2009–2018. *Am. J. Public Health* **2022**, *112*, 325–333. https://doi.org/10.2105/AJPH.2021.306571.
9. Neal, B.; Wu, Y.; Feng, X.; et al. Effect of Salt Substitution on Cardiovascular Events and Death. *N. Engl. J. Med.* **2021**, *385*, 1067–1077. https://doi.org/10.1056/NEJMoa2105675.
10. Hou, L.; Guo, X.; Zhang, J.; et al. Associations Between Salt-Restriction Spoons and Long-Term Changes in Urinary Na^+/K^+ Ratios and Blood Pressure: Findings from a Population-Based Cohort. *J. Am. Heart Assoc.* **2020**, *9*, e014897. https://doi.org/10.1161/JAHA.119.014897.
11. Xu, A.; Ma, J.; Guo, X.; et al. Association of a Province-Wide Intervention with Salt Intake and Hypertension in Shandong Province, China, 2011–2016. *JAMA Intern. Med.* **2020**, *180*, 877–886. https://doi.org/10.1001/jamainternmed.2020.0904.

12. Liu, M.; Xu, J.; Li, Y.; et al. A Town-Level Comprehensive Intervention Study to Reduce Salt Intake in China: Cluster Randomized Controlled Trial. *Nutrients* **2022**, *14*, 4698. https://doi.org/10.3390/nu14214698.
13. Jackson, S.L.; Cogswell, M.E.; Zhao, L.; et al. Association Between Urinary Sodium and Potassium Excretion and Blood Pressure Among Adults in the United States: National Health and Nutrition Examination Survey, 2014. *Circulation* **2018**, *137*, 237–246. https://doi.org/10.1161/CIRCULATIONAHA.117.029193.
14. Yin, L.; Deng, G.; Mente, A.; et al. Association Patterns of Urinary Sodium, Potassium, and Their Ratio with Blood Pressure across Various Levels of Salt-Diet Regions in China. *Sci. Rep.* **2018**, *8*, 6727. https://doi.org/10.1038/s41598-018-25097-1.
15. Bhagavathula, A.S.; Refaat, S.A.; Bentley, B.L.; et al. Association between Intake of Sodium, Potassium, Sodium-to-Potassium Ratio, and Blood Pressure among US Adults. *Int. J. Vitam. Nutr. Res.* **2023**, *93*, 392–400. https://doi.org/10.1024/0300-9831/a000740.
16. Xie, Y.; Qi, H.; Peng, W.; et al. Higher Potassium Intake and Lower Sodium Intake May Help in Reducing CVD Risk by Lowering Salt Sensitivity of Blood Pressure in the Han Chinese Population. *Nutrients* **2022**, *14*, 4436. https://doi.org/10.3390/nu14204436.
17. Iwahori, T.; Miura, K.; Ueshima, H.; et al. Estimating 24-h Urinary Sodium/Potassium Ratio from Casual (“Spot”) Urinary Sodium/Potassium Ratio: The INTERSALT Study. *Int. J. Epidemiol.* **2017**, *46*, 1564–1572. https://doi.org/10.1093/ije/dyw287.
18. Kogure, M.; Hirata, T.; Nakaya, N.; et al. Multiple Measurements of the Urinary Sodium-to-Potassium Ratio Strongly Related Home Hypertension: TMM Cohort Study. *Hypertens. Res.* **2020**, *43*, 62–71. https://doi.org/10.1038/s41440-019-0335-2.
19. Zhou, W.; Mao, X.; Dong, Y.; et al. Analysis on Implementation Progress of Basic Public Health Service Projects in Jiangxi Province from 2017 to 2023. *Medicine* **2025**, *104*, e46591. https://doi.org/10.1097/MD.0000000000046591.
20. Qin, J.; Zhang, Y.; Fridman, M.; et al. The Role of the Basic Public Health Service Program in the Control of Hypertension in China: Results from a Cross-Sectional Health Service Interview Survey. *PLoS ONE* **2021**, *16*, e0217185. https://doi.org/10.1371/journal.pone.0217185.
21. Zhang, J.; Zhang, B.; Tang, J.; et al. Deaths and Life Expectancy Losses Attributed to High-Salt Diet in Shandong Province. *Zhonghua Liu Xing Bing Xue Za Zhi* **2021**, *42*, 527–530. https://doi.org/10.3760/cma.j.cn112338-20200306-00268.
22. Anderson, C.A.M.; Appel, L.J.; Okuda, N.; et al. Dietary Sources of Sodium in China, Japan, the United Kingdom, and the United States, Women and Men Aged 40 to 59 Years: The INTERMAP Study. *J. Am. Diet. Assoc.* **2010**, *110*, 736–745. https://doi.org/10.1016/j.jada.2010.02.007.
23. Du, X.; Zhu, Y.; Guo, J.; et al. Effect of Salt Reduction Interventions in Lowering Blood Pressure and Salt Intake in Zhejiang Province, China, 2017–2021: A Randomized Controlled Trial. *Nutrients* **2025**, *17*, 893. https://doi.org/10.3390/nu17050893.
24. Duus, C.L.; Nielsen, S.F.; Hornstrup, B.G.; et al. Self-Performed Dietary Sodium Reduction and Blood Pressure in Patients with Essential Hypertension: A Randomized Clinical Trial. *J. Am. Heart Assoc.* **2024**, *13*, e034632. https://doi.org/10.1161/JAHA.124.034632.
25. Grover, S.; Mishra, H.P.; Gupta, R.; et al. Effect of Telemonitoring and Home Blood Pressure Monitoring on Blood Pressure Reduction in Hypertensive Adults: A Network Meta-Analysis. *J. Hypertens.* **2025**, *43*, 1091–1098. https://doi.org/10.1097/HJH.0000000000004008.
26. Jin, A.; Xie, W.; Wu, Y. Effect of Salt Reduction Interventions in Lowering Blood Pressure in Chinese Populations: A Systematic Review and Meta-Analysis of Randomised Controlled Trials. *BMJ Open* **2020**, *10*, e032941. https://doi.org/10.1136/bmjopen-2019-032941.
27. Sonuch, P.; Aekplakorn, W.; Pomsanthia, N.; et al. Community-Based Intervention for Monitoring of Salt Intake in Hypertensive Patients: A Cluster Randomized Controlled Trial. *PLoS ONE* **2024**, *19*, e0311908. https://doi.org/10.1371/journal.pone.0311908.
28. Takada, T.; Imamoto, M.; Sasaki, S.; et al. Effects of Self-Monitoring of Daily Salt Intake Estimated by a Simple Electrical Device for Salt Reduction: A Cluster Randomized Trial. *Hypertens. Res.* **2018**, *41*, 524–530. https://doi.org/10.1038/s41440-018-0046-0.
29. Shimoyama, M.; Kawamoto, S.; Nakatani, Y.; et al. Effects of Salt Intake Reduction by Urinary Sodium to Potassium Ratio Self-Monitoring Method. *Hypertens. Res.* **2024**, *47*, 1852–1860. https://doi.org/10.1038/s41440-024-01655-1.
30. Zhang, X.; Zhang, P.; Shen, D.; et al. Effect of Home Cook Interventions for Salt Reduction in China: Cluster Randomised Controlled Trial. *BMJ* **2023**, *382*, e074258. https://doi.org/10.1136/bmj-2022-074258.
31. Zhang, W.; Neupane, D.; Zhao, Z.; et al. Knowledge and Practices Related to Salt Consumption in China: Findings from a National Representative Cross-Sectional Survey. *J. Hum. Hypertens.* **2024**, *38*, 155–167. https://doi.org/10.1038/s41371-023-00861-7.
32. Mizuta, E.; Kitada, K.; Nagata, S.; et al. Effect of Population-Based Sodium Reduction Interventions on Blood Pressure: A Systematic Review and Meta-Analysis of Randomized Trials. *Hypertens. Res.* **2025**, *48*, 1899–1910. https://doi.org/10.1038/s41440-025-02181-4.
33. Sanoff, S.L.; Klemmer, P.J.; Neelon, F.A.; et al. Treating Malignant Hypertension with the Low-Sodium, Low-Protein, and Low-Fat Rice Diet. *Hypertension* **2026**, *83*, 26–36. https://doi.org/10.1161/HYPERTENSIONAHA.125.25073.