A Meta-Analysis of Effect of Dietary Salt Restriction on Blood Pressure in Chinese Adults

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ABSTRACT

The aim of this study was to estimate the effects of dietary salt reduction on blood pressure (BP) in Chinese adults and the effects of China-specific cooking salt-reduction strategies (the use of salt substitutes and salt-restriction spoons). The PubMed and China National Knowledge Infrastructure databases were searched for studies satisfying the search criteria. Outcomes extracted from each included study were 24-h urinary sodium excretion, salt (sodium chloride) intake, and BP before and after dietary salt lowering. A random-effects meta-analysis was performed, and results were evaluated for evidence of publication bias and heterogeneity. Because most studies aggregated results for hypertensive and normotensive participants, estimates were made for hypertensive participants only and for hypertensive and normotensive participants combined. Six salt-restriction experiment studies (3,153 participants), 4 cooking salt-restriction spoon studies (3,715 participants), and 4 cooking salt-substitute studies (1,730 participants) were analyzed. In salt-restriction experiment studies, the pooled estimate of mean change in 24-h urinary sodium excretion in hypertensive participants was −163.0 mmol/day (95% confidence interval [CI]: −233.5 to −92.5 mmol/day), which was associated with a mean reduction of −8.9 mm Hg (95% CI: −14.1 to −3.7 mm Hg) in systolic BP. Each 1.00-g dietary salt reduction in hypertensive participants was associated with a reduction of 0.94 mm Hg in systolic BP (95% CI: 0.69 to 1.03 mm Hg). These systolic BP reductions in hypertensive participants were 1.71 times greater compared with the mixed hypertensive and normotensive group. Salt-restriction spoon studies demonstrated a 1.46-g decrease in daily salt intake level. The effect of salt-substitute use on systolic BP control was substantial among the hypertensive participants (−4.2 mm Hg; 95% CI: −7.0 to −1.3 mm Hg), but the change did not reach statistical significance in hypertensive and normotensive participants combined (−2.31 mm Hg; 95% CI: −5.57 to 0.94 mm Hg). Salt restriction lowers mean BP in Chinese adults, with the strongest effect among hypertensive participants. Future studies of salt-restriction strategies should be report results stratified by hypertension status and adjust for medication use.

Blood pressure (BP) is one of the most important modifiable risk factors for cardiovascular diseases in China [1]. Mean national consumption is more than 12 g/day of salt (sodium chloride), a level higher than in most other countries [2,3]. Dietary salt reduction may be an effective population-wide approach to reducing disease burden attributable to elevated BP in China.

Dietary salt-lowering programs have been launched in China, but the effect of salt reduction on BP in Chinese adults has not been reviewed and summarized. Past meta-analyses reported that salt restriction was consistently and linearly associated with BP reduction, with greater BP reductions in hypertensive patients [4–6]. These studies showed larger reductions in BP associated with the same reductions in dietary salt in adults of recent African ancestry compared with Caucasians, but few participants of East Asian ancestry were selected for the studies reviewed [5,7].

Unlike in Western countries, most dietary salt is added in home cooking in China [3]. Culturally tailored cooking salt-restriction strategies have been developed that target salt added in cooking in China, including the use of cooking salt-restriction spoons and cooking salt substitutes [8–10]. The purpose of this meta-analysis was to summarize the effects of sodium restriction and sodium substitution on BP in Chinese adults.

METHODS

Eligibility criteria

To explore the effects of salt change on BP change in ethnic Chinese adults, salt-restriction studies were considered for review if they satisfied the following criteria: (1) papers reported on intervention studies or randomized controlled trials conducted in Chinese participants; (2) change in BP was due only to the change in sodium, that is, without other dietary changes; (3) salt intake was estimated by 24-h urinary sodium testing; (4) pre- and post-intervention mean salt intake and standard deviation were reported; (5) pre- and post-intervention or change in mean BP and standard deviation were reported; (6) duration of salt-reduction intervention was at least 1 week; and (7) participants were ≥35 years of age.

The authors report no relationships that could be construed as a conflict of interest.
This research was supported by grants from the National Program on Key Basic Research Project of China (contract no. 2012CB517806), the National Science & Technology Pillar Program during the 12th Five-Year Plan Period (contract nos. 2011BAI09B01 and 2011BAI11B03), and the Capital Health Research and Development of Special (contract no. 2011-1005-01) to Drs. Zhao and Liu; a Mentored Career Development Award (contract no. K08HL089675) from the National Heart, Lung, and Blood Institute of the U.S. National Institutes of Health to Dr. Moran; and the Wu Yingkai Foundation for Medical Research and Development to Dr. Wang. The funders of the study had no input regarding study design, data analysis and interpretation, or writing of the paper.
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GLOBAL HEART

VOL. 10, NO. 4, 2015
ISSN 2211-8160/$36.00.
http://dx.doi.org/10.1016/j.gheart.2014.10.009

Cooking salt-restriction spoon studies only measured change in salt. We therefore explored the effect of salt-restriction spoon use on change in salt intake level alone. The inclusion criterion for salt-restriction spoon studies was salt intake level estimated by 24-h urinary test or salt directly weighed before cooking. Otherwise, the aforementioned criteria (1, 2, 4, 6, and 7) for salt-restriction studies were met (Online Table 1).

Cooking salt-substitute studies used a formulation composed of 65% sodium chloride, 25% potassium chloride, and 10% magnesium sulfate. As a result, the effect of salt substitution on BP was due to the contributions of multiple components, and BP could decrease because of lower sodium intake, higher potassium intake, or both. Salt-substitute studies measured changes in BP, urinary sodium, and urinary potassium. In recent studies, sodium and potassium were estimated from the first morning urinary collection. Because this measurement was not the gold standard, we analyzed only change in BP due to the salt substitute. Salt-substitute studies had to fulfill criteria 1, 5, 6, and 7 for salt-restriction studies (Online Table 1).

Outcome measures

The outcomes extracted from each study were the changes in sodium, salt, systolic BP, and diastolic BP. Data on region of China (north or south), mean and range of participants' ages, sex, and hypertension status were also extracted from the papers for the purpose of potential stratified analyses. Because most studies did not report on effects in hypertensive and normotensive participants separately, we were only able to stratify into groups of hypertensive participants only and the combination of hypertensive and normotensive participants.

Search strategy

Electronic databases, international conference reports, reference lists of articles, and a prior Cochrane review were searched by one study investigator (M.W.). We searched the National Library of Medicine's MEDLINE database for English-language papers and the China National Knowledge Infrastructure's database for articles written in Chinese. There were no language limits in the 2 search strategies. The last search was run on July 1, 2014. The search terms used in this study are listed in Table 1. For the search for cooking salt-restriction or salt-substitute intervention studies in China, we added the term "salt-restriction spoon" or "salt substitute" in the title, abstract, and key words, then screened any additional studies not captured in the original electronic search.

Study selection and data extraction

Two investigators (W.M. and A.M.) reviewed the included studies once full-text reports were obtained and results were translated into English. A third reviewer (D.Z.) resolved disagreement between the 2 primary reviewers. A data extraction sheet was developed to collect key information, including characteristics of the study and participants (age, sex, region, sample size, published year, and hypertension status of the participants), methods of intervention (type and duration), methods of salt intake measurement, pre- and post-intervention salt, urinary sodium and potassium, and BP for data collection and risk for bias estimation. Each study was evaluated to find any additional reporting on subgroups (such as data stratified by sex or hypertension status; Online Tables 1–4) [8–21].

Method of analysis

The meta-analysis was done using Stata 12 meta-analysis software (StataCorp LP, College Station, Texas) using random-effects models. The effect of salt intake change on BP was calculated by dividing the pooled change in BP (in millimeters of mercury) by the pooled change in reduced salt (1 g salt = 0.393 g sodium, 1 g sodium = 43.5 mmol sodium) from the meta-analysis. Only 1 study did not report the standard deviation of the post-intervention BP [19]. In this case, the standard deviation of pre-intervention BP was used as a proxy (Online Table 2). We qualitatively assessed the risk for bias in individual studies associated with the sampling strategy, study design, randomization, blinding, selection and use of control participants, intervention duration, and method of salt-intake estimation. Begg's and Egger's tests were also applied to quantify potential publication bias.

To assess for evidence of heterogeneity, we estimated the I^2 statistic. We also evaluated the data for effect measure modification by selected variables by conducting a meta–regression analysis with the change in systolic BP as the dependent variable and age (mean age of the participants in each study), sex, and hypertension status (hypertensive only or mixed hypertensive and normotensive) as the independent variables. A p value < 0.05 assigned to comparison of adjusted means was considered to indicate statistical significance.

RESULTS

Effect of salt restriction on BP

Six studies representing 3,153 participants were included in the meta-analysis of the effect of salt restriction on BP [16–21]. The summary changes in sodium (in millimoles per day) and BP are listed in Figures 1 to 3. In hypertensive participants, salt level decreased by 9.6 g (163.0 mmol sodium), which was associated with an 8.91 mm Hg systolic BP reduction and a 5.88 mm Hg diastolic BP reduction (Table 2). Each 1-g dietary salt reduction in hypertensive participants was associated with a reduction of 0.94 mm Hg (95% confidence interval [CI]: 0.69 to 1.03 mm Hg) in systolic BP and of 0.62 mm Hg (95% CI: 0.38 to 0.71 mm Hg) in diastolic BP. For the same dietary salt reduction, systolic BP change due to salt restriction was 1.71 times greater in the hypertensive-only group compared with the mixed hypertensive and normotensive group.