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Effects of Dietary Salt on Blood Pressure

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Abstract

Objective: The main objective of this study is to find out the effects of dietary salt on BP in a general adult population, and to perform a systematic review of all published and non-published available scientific literature on dietary salt in relation to BP.

Methods: Online search of electronic databases, Cochran systematic reviews, PubMed central, electronic journals, citation searching and Google scholar search were used to identify studies on the association between sodium and BP. A total of 67 papers were retrieved, 10 of which met the inclusion criteria and were included in the review. The authors selected the studies, extracted the data and performed narrative analyses. Most studies showed a positive association between total dietary salt and BP. The results of randomized control trials have shown a significant effect of sodium on BP. Some evidence showed that people with elevated BP and/or elders could be more sensitive to dietary salt.

Results: Four trials with normotensive individuals (n=2326) and six trials with stage 1 hypertensive (n=387) were included, with follow up from 28 days to 1095 days. Six, high quality (and therefore most informative) studies and four neutral quality trials used intensive behavioral interventions. Both systolic and diastolic BP were reduced at 1 to 39 months in those given a low salt diet as compared with a usual salt (systolic by 1.7 mm Hg to 12.6 mmHg, diastolic by 0.9 mm Hg, to -10.9 mmHg), as was urinary 24-hour sodium excretion (by 42 mmol per day, to 78 mmol per day). The reduction in sodium intake and the change in BP were not related.

Conclusions: Evidence suggests a small but beneficial effect of reduced dietary salt on BP, with benefits that extend to both non-hypertensive and mild to moderate hypertensive patients. A BP lowering effect of a low sodium diet may have important public health implications, although no clear dose response association could be distinguished. Furthermore, more data are needed on dietary salt from specific sources in relation to BP, and on the salt - BP relations in population subgroups.

Keywords: NaCl; High BP; Hypertension; Salt; Systolic and diastolic blood pressure; 1 RCT's; Dietary-sodium-restriction; Randomized controlled trials; Common dietary-salt; Parallel-trials; Crossover-trials

Introduction

BP is calculated as the product of a stroke volume of the left ventricle of the heart, heart rate and peripheral resistance in the vessels of the body. Hypertension refers to a chronic elevation of BP beyond levels known to increase the risk of cardiovascular related morbidity and mortality and is the greatest contributor to impaired health in the world [1]. It has long been known that hypertension increases the risk of both stroke [2] and myocardial infarction [3] independently of the other known risk factors. Such factors are long-term high sodium intake [4], insufficient amount of intake of potassium and calcium, excessive alcohol intake and sedentary lifestyle [5]. Given the BP eliminating effects of these environmental factors, it is irrational to speculate that if genetically predisposed individuals were exposed to these factors the BP elevation would be substantial.

Salt is a chemical compound made up of sodium and chloride (40% and 60% respectively). Sodium is readily used in chemical industries and in the food industries. It is not only an essential component of the body but it also has an important role in controlling and maintaining the volume of extracellular fluid, regulation of acid-base balance and maintaining the action potential between cells. The major source of sodium is foods and liquids (beverages and drinking water). The studies found that males are the larger consumers of high salt in their food. The FDA US found that most adults consume between 5 and 6 grams of salt per day, whereas some adults consume more than 10 g per day. Hypothesis is that the high amount of salt in our food leads to high BP and ultimately increases their risk of cardiovascular events.

The aim of this study is to search the best evidence available to assess the effects of dietary salt on BP, using a systematic approach to examine the effects of restricted dietary sodium intake on resting systolic and diastolic BP in the general population.

Literature Review

Evidence suggests that the effects of mild to moderate restriction in dietary sodium intake on BP are modest. There are many reviews and analyses of experimental and observational studies that there are less significant or no benefits in reducing salt in our daily diets. However, some of these drives were short duration and based on small sample sizes. The lack of good quality interventional studies and the presence of observational studies with insufficient rigor have led to less than overwhelming the results. Our objective is to define safe limits for dietary consumption of salt in a general population and to explore the trends of BP in relation to dietary salt intake among the general population.

Methods

Literature search strategy

The best evidence available was searched from multiple sources

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without any language or regional restrictions (Figure 1). The most recently published version of studies has been identified by systematic Cochrane search strategy. Articles were retrieved via the Cochrane controlled clinical trials register, PubMed central database, Medline, CINAHL, EMBASE, BMJ, hypertension or journal of hypertension.

Criterions for considering literature for review

The specific criterion has been established for considering literature for review. For example interventional trials that use mild to moderate changes in salt intake in regular diet as the primary intervention and must have at least 4 weeks of duration trials are included in this review.

Inclusion criteria

Types of population shall include; adults aged 12 years and above, hypertensive (stage 1) or non-hypertensive from any background without any co-morbid conditions such as Diabetes mellitus (Type I or type II), hyperlipidemia, Obesity or other major illness, Clinical trials which using moderate to high levels of common salt in their regular diet are included in this review.

Individuals shall have been recruited based on a systematic random sampling technique and or random allocation into either an intervention group or control group.

Exclusion criteria

Infants and children aged less than 12 years, population in a hospital and in acute care setting, critical care patients, and patients with any kind of heart disease or any other major illness and trials with very small size of population shall be excluded. Trials less than 4 weeks of duration also been excluded from the review.

Data Collection and Analysis

Data from studies were extracted and tabulated initially and later synthesized by the narrative approach. The data collected included citation, author's first name, publication year, and purpose of the study, descriptive summary of the participants, intervention, outcome results, author's conclusion, study limitations and source of financial support.

Results

Search of eligible studies

Literature search results identified total 68 articles from all

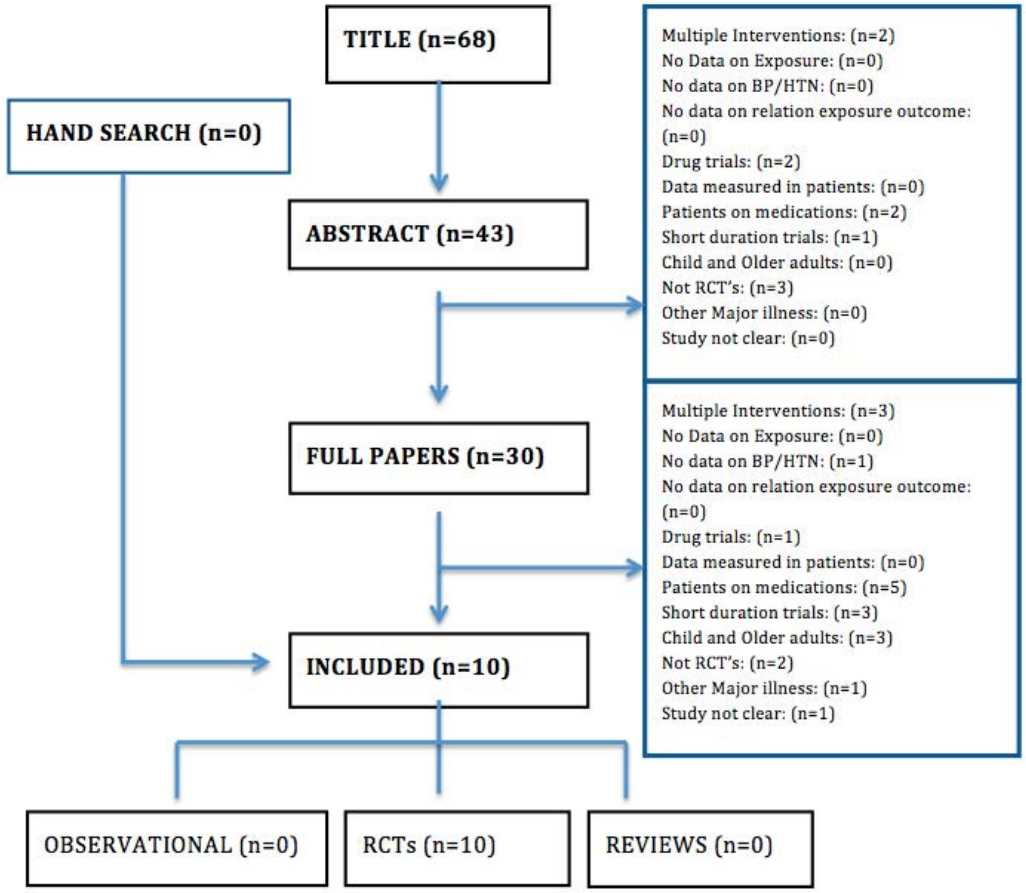

Figure 1: Flow diagram of literature search results.

databases, 10 potential articles were selected for final review. Brief statement of the relevant findings of each study Obarzanek et al.

This group studied 188 patients (54.8% women and 57.5% blacks), aged 22 years and above (69.9%>45 years), with mean BMI of 29.6 kg/m^2, who were normotensive or had upper normal BP, to determine the variability and consistency of the individual SBP response to a change in salt intake. Subjects were assigned to an initial 2-week run-in period on a typical American diet followed by a 3-month intervention period on one of the two dietary patterns (a control diet or DASH-diet) at 3 levels of sodium intake, each for 30 days in a 3 period crossover design. The results were variable over time and identifying individual response was difficult than groups. They also concluded that the variability can be because other reasons than diet. The study showed significant changes in BP with response a 77 mmol per day difference in sodium intake. The main purpose of the study, however, was not achieved as a result of the study design.

This randomized, crossover study examined the effects of dietary sodium restriction on large elastic artery compliance and BP. Twelve untreated US adults (six men and six women; age 64 ± 2 years) with stage one systolic hypertension were assigned to four weeks of low (57 mmol per day) or normal (135 mmol per day) sodium intake. Participants ate a reduced sodium diet during each period; the contrast in total dietary sodium intake was then achieved with pills (either placebo or slow-release sodium chloride). The amount of pills was titrated to achieve the mean baseline levels of sodium intake. Urinary sodium excretion showed a significant reduction by 60% by the end of the first week of sodium restriction (54 ± 11 mmol per day, P<0.01) vs. baseline (135 ± 14). There was no consistent difference in carotid artery compliance between the low and usual sodium periods. During week's two to four, 24-hour ambulatory systolic BP was reduced by approximately 6 mmHg in the low compared to the usual sodium intake period.

This community-based, randomized cluster trial, conducted in 12 rural and semi-urban West African villages, examined the effect of health promotion intervention to reduce salt intake on BP. Subjects included 1,013 participants (628 women, 481 rural dwellers) whose mean age was 55 years, average BP was 125/74 mmHg and urinary sodium excretion (UNa) was 101 mmol per day. Urinary sodium excretion and BP levels were assessed at three and six months for all groups. There was no significant change in urinary sodium excretion in the intervention villages but the group experienced a non-significant decrease in systolic BP [2.54 mmHg (-1.45 to 6.54)] and a significant decrease in diastolic BP [3.95 mmHg (0.78 to 7.11), P=0.015), net of change in the control group. In analyses that included all participants, regardless of intervention, there was a direct relationship between the fall in urinary sodium excretion and the fall in BP after adjusting for confounders. A difference in 24-hour urinary sodium of 50 mmol was associated with a lower systolic BP of 2.12 mmHg (1.03 to 3.21) at three months and 1.34 mmHg (0.08 to 2.60) at six months (both P<0.001).

This multi-center randomized and controlled trial, conducted in the US, examined the relationship between sodium intake and BP change in 18-month and 36-month periods using data from the Trials of Hypertension Prevention (TOHP) Phase II (sodium intervention phase). The original TOHP II subjects were assigned to receive one of the following: counselling for weight loss only, counselling for sodium intake reduction to 80 mmol per day, counseling for weight loss and sodium intake reduction to 80 mmol per day, or usual care with no study-delivered intervention. The sodium intervention groups were combined for analysis; 1,157 overweight, non-hypertensive men and women were randomized and 880 subjects completed the three-year trial (437 with sodium reduction intervention and 443 in the usual care). At 36 months, there were significant differences between the sodium reduction group and usual care group in the change of urinary sodium excretion (-50.9 mmol per day vs. -13.2 mmol per day, P<0.0001), urinary sodium/ potassium ratio (-0.62 vs. 0.06, P<0.0001), systolic BP (-1.2 mmHg vs. 0.5 mmHg, P=0.003) and diastolic BP (-3.3 mmHg vs. -2.4 mmHg, P=0.04). At 36 months, there was a significant trend between systolic BP decrease and lower quintiles of achieved sodium excretion (P=0.005), but not with diastolic BP (P=0.67). In analyses that corrected for measurement error, the estimated mean reduction in systolic BP from a 100 mmol per day reduction in sodium was 7.0 mmHg at 18 months and 3.6 mmHg at 36 months. In other analyses, those individuals who maintained reduced sodium intake had significantly lower systolic BP compared to those who did not reduce their sodium intake.

This randomized crossover study examined the effects of low and high salt diets on BP response in 114 normotensive adults living in Nigeria (N=58) and Jamaica (N=56). After a four week baseline run-n period to determine the willingness to adhere to a low salt diet, subjects completed a two-period crossover study of low salt and high salt intake. Each period lasted three weeks, with an intervening two-week washout. Participants were counselled to follow each diet. Baseline urinary sodium excretion rates were 86.8 and 125.6 mEq per day in Nigeria and Jamaica, respectively. Mean baseline systolic BP was 125 mmHg in Jamaica and 114 mmHg in Nigeria. Mean urinary potassium excretion was approximately 50 mmol per day in both countries. After adjustment for baseline characteristics such as sodium excretion, period effects, age and sex, the net (absolute) changes in urinary sodium excretion between the low salt and high salt interventions was 14.6 mEq per day and 46.8 mEq per day in Nigeria and Jamaica, respectively. The mean difference between baseline sodium excretion and low sodium phase was 33.6 mEq per day in Nigeria and 57.5 mEq per day in Jamaica. The mean change in systolic BP between the low to high sodium interventions in both countries was approximately 5 mmHg, suggesting that the efficacy of sodium reduction in developing countries equals those noted in more affluent cultures.

This randomized crossover trial was conducted in the United Kingdom and determined the effects of a moderate salt reduction on BP and urine protein excretion in 47 non-diabetic black hypertensive subjects. After a run-in period of four weeks of the usual diet, followed by an additional run-in period of two weeks on a reduced salt diet (approximately 5 grams salt per day) diet, participants received either 12 slow-sodium tablets (10 mmol or 220 mg of sodium per tablet) daily to bring their salt intake back to normal or 12 placebo tablets daily for four weeks. In 40 subjects who completed the study, reducing salt intake from approximately 10 grams to 5 grams per day decreased BP from 159/101 ± 13/8 mmHg to 151/98 ± 13/8 mmHg (P<0.01). Mean protein excretion fell from 93 to 75 mg per day (P<0.008).

This single center case control study enrolled 80 patients (60 cases plus 20 controls) with mild to moderate BP elevation but not taking any medication. Mean age was 48.7 years for cases and 46. 1 year for controls. This 6-week trial was based on a comparison between a regular high salt diet and low salt diet (DASH-diet). Cases were divided into 3 groups, low (21% of subjects), medium (52%) and high (26%) salt intake with similar percentages for controls. Weight, urinary sodium excretion and BP levels were measured at baseline then after 6 weeks on a controlled diet, low medium and high salt diets. Mean systolic BP and systolic BP during the day decreased by 12.1 and 6.8 mmHg, respectively, while mean systolic BP and diastolic BP during the night decreased by 11.1 and 5.9 mmHg. Urinary sodium in 24 hours fell by

37.1 ± 39.67 mEq per dl cases and increased by 10.7 ± 26.07 mEq per dl in the control group (P=0.001). The study showed that despite modest effects on sodium restriction, a 'no added salt diet' could effectively reduce both systolic and diastolic BPs during 24 hours. Simple advice on the limiting of salty foods and not to use table salt could significantly reduce BP in both men and women.

This randomized controlled trial, conducted in Finland, assessed the effects of a dietary sodium reduction on BP response and heart rate variability in 80 persons with essential hypertension (systolic BP of 160 to 200 mmHg and diastolic BP of 90 to 110 mmHg). Forty persons were randomized to six months of a low-sodium diet (daily sodium intake reduced to less than 70 mmol, general advice to lose weight if necessary, and general advice to reduce intake of saturated fats) and 40 were assigned to the control group (not described, but previously reported). Although BP was significantly reduced after six months in the sodium restriction group (systolic BP from 149.9 ± 14.7 to 130.3 ± 11.8 mmHg, P<0.001 and diastolic BP from 98.0 ± 6.4 to 87.1 ± 6.2 mmHg, P<0.001), similar changes were seen in the control group. No correlation in changes of heart rate variability (HRV) was found in relation to sodium intake during the study. In addition to BP, the energy intake was reduced in both the intervention as well as the control groups (p<0.001) and (p<0.05) respectively. Body mass index was reduced in the intervention group (p<0.001) but remained the same in the control individuals with a wide difference in change between intervention and control groups (P<0.001). Physical activity did not change in both groups.

This randomized crossover study compared the effects of a low salt diet (50 mmol sodium per day) with those of a usual salt diet (150 mmol sodium per day) on flow-mediated dilatation (FMD). Subjects included 29 overweight and obese normotensive Australian men and women who followed a low salt diet and a usual salt diet for two weeks. Participants received diet counselling on how to achieve the intended dietary goals. The diets were designed to ensure weight stability and had similar potassium and saturated fat contents. BP, pulse wave velocity and FMD was measured by the end of each two-week intervention period. The 24 hour sodium excretion was significantly lower (P=0.0001) with the low salt diet (64.1 ± 41.3 mmol) than with the usual diet intake (156.3 ± 56.7 mmol), while urinary potassium excretion rates were similar. FMD was greater (P=0.001) with the low salt diet (4.89 ± 2.42%) than with the usual salt diet (3.37 ± 2.10%), and systolic BP was significantly (P=0.02) lower with the low salt diet (112 ± 11 mmHg) than with the usual salt diet (117 ± 13 mmHg). No significant changes in augmentation index or pulse wave velocity were recorded. There was no correlation between changes in FMD and changes in 24-hour sodium excretion as well as changes in BP. The authors concluded that salt reduction improved endothelium- dependent vasodilation in normotensive subjects independent of changes in BP, suggesting additional cardio-protective effects of salt reduction beyond BP reduction.

This randomized, double-blind crossover trial, conducted in London, England, examined the effects of a modest reduction in salt intake on BP, 24-hour urinary albumin excretion and pulse wave velocity in three ethnic groups with untreated, mildly raised BP. Participants included 71 whites, 69 blacks and 29 Asians, aged 30 to 75 years, with sitting systolic BP of 140 to 170 mmHg or diastolic BP of 90 to 105 mmHg. All subjects consumed a reduced salt diet for the first two weeks of the study, and then were randomized to either slow sodium or placebo for six weeks, followed by a crossover to the opposite tablets for an additional six weeks. From slow sodium to placebo, urinary sodium was reduced from 165 ± 58 to 110 ± 49 mmol per 24 hours (9.7 to 6.5 grams salt per day, respectively). BP decreased from 146 ± 13 / 91 ± 8 to 141 ± 12 / 88 ± 9 mmHg (P<0.001), urinary albumin from 10.2 (IQR: 6.8 to 18.9) to 9.1 (6.6 to 14.0) mg per 24 hours (P<0.001), albumin/creatinine ratio from 0.81 (0.47 to 1.43) to 0.66 (0.44 to 1.22) mg per mmol (P<0.001) and carotid-femoral pulse wave velocity from 11.5 ± 2.3 to 11.1 ± 1.9 m per second (P<0.01).

Evidence Summary

A literature search identified 68 potential articles with multiple primary study designs. A total of 10 articles met the eligibility criteria. Eight were randomized trials that studied and tested different levels of sodium intake on pre-defined populations where the primary outcomes were effects on BP and urinary sodium excretion. One study is an observational analysis of a previously published trial "TOHP Phase 2" [2]. One study is a case/control study to evaluate the effect of 'no added salt diet' on a hypertension population. Participant selection varied between studies; four studies enrolled normotensive individuals, while six enrolled stage 1 hypertensive individuals. None of these study participants were on any medications before or during the trial [6]. Another similarity among studies is the age limit. There were no children involved in these studies. Studies included in the review are multinational trials that were conducted in the USA, Australia, Africa, Finland, Great Britain, Iran, Jamaica and Nigeria. Populations were demographically heterogeneous (e.g., enrolling black, white and Asian hypertensive living in Great Britain). Many previous studies showed that sodium reduction leads to lowering of BP, but these individual trials typically addressed other issues as well, such as the effects of dietary interventions on economy in both developed and non-developed countries and the effects of sodium reduction on other variables (e.g., vascular function, arterial compliance, proteinuria and heart rate variability). However, each proved the effects of sodium reduction on BP. Overall, a significant reduction in either systolic or diastolic BP occurred in all trials quite apart from other effects. The eight high quality studies and two neutral quality studies showed a significant reduction in systolic or diastolic BP. In some studies, relatively few BP measurements were obtained; hence, in some cases, the absence of significant findings might have resulted from inaccurate or inadequate BP measurement. One study [7] tried to find out the variability and consistency of individual BP response to changes in salt intake (Appendix 1).

In summary, these studies support and further strengthen the previous conclusions that less use of sodium in the diet has a significant effect on and lowers BP, with benefits that extend to both non-hypertensive and hypertensive individuals.

Discussion

Eight different randomized controlled trials of moderate dietary salt restriction, one observational review of a randomized controlled trail (TOHP Stage II) and one case-control study [6] including 2605 participants provide significant evidence in favor of a reduction in systolic and diastolic BP and urinary sodium excretion at lower levels of salt intake (Appendix 2). The large amount of data in these 10 trials suggest that if we could reduce salt in our daily diet, we may help people to optimize their BP and help patients on anti-hypertensive to stop using or use less medication without losing BP control. Apart from BP, some studies show the effects of low salt intake on 24-hour urinary protein excretion [8], pulse wave velocity [9], and other measures of vascular functions, namely aortic pulse wave velocity and augmentation index [10], heart rate variability [11], carotid artery compliance in the middle aged to older men and women [12], and variability and consistency of individual systolic BP responses [7].

What is already known on this topic?

Many epidemiological studies have proven a clear association between excess sodium intake and BP. Apart from these studies, multiple systematic reviews and meta-analyses of randomized controlled trials with other population based intervention trials have also shown that there is a possibility of achieving a major decrease in both systolic and diastolic BP if we reduce moderate to severe amounts of salt in our daily diet, an effect that should be seen for both hypertensive and non-hypertensive populations.

What this study adds

Moderate to higher levels of salt intake in different populations with different age groups is associated with significantly higher levels of BP in both hypertensive and non-hypertensive subjects that may lead to higher incidences of strokes and total cardiovascular events in the general population. My review however, has not shown a dose-dependent association of dietary salt and BP. Results found the effect of reduced dietary sodium intake on the cardiovascular system.

A major weakness of current review is that It was unable to obtain information on the overall effect of reduced salt intake on the cardiovascular system but have tried to review effects of reduced salt intake on Blood Pressure, 24-hour urinary sodium excretion and other factors like 24 hour urinary protein excretion, heart rate variability, vascular endothelial function and carotid artery compliance in older adults. One study suggested that a moderate reduction in salt after middle age rapidly normalizes systolic BP. This may be facilitated by an increase in large elastic artery compliance [12]. Another study reported that apart from decreases in both systolic and diastolic BP, no changes were seen in cardiac parasympathetic nervous control, as measured by heart rate variability. In contrast, another study showed that a sodium restriction diet improved endothelial function, assessed by Flow-Mediated Dilatation (FMD), relative to the usual diet, in obese subjects (Appendix 3). Changes in FMD were unrelated to changes in BP, suggesting that a mechanism other than a change in BP is responsible for the effects of salt on FMD. Feng et al [9] suggest in their study that a modest reduction in salt reduces carotid-femoral pulse wave velocity, indicating an improvement in large artery compliance.

Results found the effects of reduced dietary sodium intake on Blood Pressure and urinary sodium excretion:

Current analysis shows that both urinary sodium excretion and Blood Pressure fell significantly in many trials [6,8,11,13,14], put dates in but not in all. One study [7] showed a significant reduction in systolic BP of 77 mmol of sodium per day (-6.7 mmHg; P<0.0001) compared with no change in sodium intake (-1.9 mmHg). But in terms of an individual response, only 33% of subjects dropped systolic BP by more than 10 mmHg, while 55% showed a systolic BP drop of greater than 5 mmHg, 6% had an increase BP greater than 5 mmHg and 1.1% showed an increase of 10 mmHg or more in systolic BP [7]. This group finally concluded that it is necessary to use a different study design to identify individuals with salt sensitivity. Another study, however, concluded that moderate reduction of salt in middle-aged and elderly adults with stage 1 hypertension rapidly normalizes systolic BP, which may be mediated by an increase in large elastic artery compliance [12]. One large, double-blinded trial [9], which involved a large number of individuals from other ethnic communities, showed that a moderate decrease in dietary sodium intake might produce a significant reduction in BP in 3 different ethnic groups with mildly raised BP. They also added, that long- term reduction in salt intake might reduce urinary protein (albumin) excretion in subjects with high BP and also improve large elastic artery compliance and decrease urinary calcium excretion [9]. Another study [8] found that even a modest salt reduction from 10 to 5 grams per day reduced BP and urinary albumin excretion in non-diabetic black hypertensive (mean decrease in protein excretion with salt reduction was 18 ± 39 mg per day (P < 0.008).

What could be done in the future to prevent salt overload in our diets

Despite strong evidence that high consumption of dietary salt leads to high BP and is linked with an increased risk of cardiovascular events, salt intake in developed and non-developed countries is more than double the recommended amount (5 grams=87 mmol per day) [15]. There is no doubt that a moderate reduction in salt intake in the general population would have a significant beneficial impact on health and reverse 8.5 million cardio-vascular related deaths worldwide within a period of 10 years [16]. WHO concluded in one large meta- analysis that management of cardio-vascular diseases accounts for 11% of total health expenditure [17], while the cost of a sodium reduction strategy would only be a small fraction of the total cost to treat cardiovascular diseases.

Salt restriction has been proven to be an effective way to reduce BP in the general population. However, support is often required. Counselling at an individual level may be effective but it would not be feasible at a population level. Sodium restricted diets require changes in dietary behavior that are difficult to develop. Some researchers suggest that an overall reduction in sodium intake could be achieved by reducing the sodium content of processed foods, which contribute 75% of total sodium intake [18-20]. A World Health Organization report (Reducing Salt Intake in Populations) underlines the need to work directly with food manufactures for any national salt reduction campaign [15]. The United Kingdom and Finland are the only two countries that use two strategies aimed at this approach, namely public health promotion and a sodium-in-food labelling system. They are different, however, in their approaches to sodium reduction within the food industry [20].

The UK uses a stealth method, leading to a gradual decrease in salt in processed foods that is hardly noticeable by the general population [21]. However, it is based on setting reduction targets for product categories, and industries should achieve this target within a given time period. This approach has proved successful in that it has reduced the sodium content in supermarket foods by 20 to 30%. This reduction expect to be doubled when revised targets are set for further decrease to meet the UK's daily intake target of 6 grams per day by 2012 [9]. Finland uses a different approach, by replacing dietary salt with sodium-reduced but potassium and magnesium-enriched mineral salt called 'Pansalt' (IMI life Products, 2006). This approach has successfully reduced salt intake from 12 to 9 grams per day [9].

Strengths and Limitation of the Review

There are several strengths and limitation in this review. The project was complex, with first time practice and a high level of practical difficulties, despite the clearly defined research question. The methodology of the review is clearly defined and transparent [22]. Moreover, reproducible inclusion and exclusion criteria of the included trials are clearly mentioned with detailed search strategy (Appendix 4).

The review also has some limitations such as publication bias, because it includes only published primary literature. Secondly, there might be an absence of other relevant and potential publications, as only one reviewer performed the literature search. Further limitations are related to the language bias. The review only included the English

language literature, as the reviewer was unable to perform an extensive and thorough literature search around all electronic databases and any other source of literature due to the short period of time available. Apart from these practical limitations, the trials included in the review displayed some methodological weakness, raising doubt about their validity; for example some were based on small participant populations [8,10,12].

Conclusions and Future Implication

Evidence suggests a small but statistically significant effect on BP lowering of a reduction in salt intake, although no clear dose response association could be identified [23]. The inclusion of eight randomized controlled trials with two other design studies has shown that there are greater chances to reduce both systolic and diastolic BP if salt in our daily diets could be restricted to no more than 5 grams per day. However, the long-term control of dietary salt in general population is a highly difficult task (Appendix 5). Formulation of different policies of salt reduction by cutting down sodium in processed and ready-made foods at industrial and manufacturing levels could prove a potential way of achieving a small but significant reduction in BP in the general population.

Although, high BP is an independent risk factor for cardio-vascular disease, other direct or indirect benefits of reducing dietary salt on cardio-vascular mortality and morbidity are unclear and needs further research. More data on salt from different sources, like processed food, and data in population subgroups should be obtained from other epidemiological studies. Furthermore, there is a requirement for BP and salt trials that focus on the effect of salt on other dietary factors (like potassium, calcium, and magnesium). There is strong need for long-term research to explore the ultimate effects of salt reduction on BP and advice especially for people with mildly elevated BP.

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