Original article

Impact of a community-based lifestyle intervention program on blood pressure and salt intake of normotensive adult population in a developing country

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Background: Data on the effect of lifestyle intervention programs on salt intake and blood pressure in developing countries are scarce. This study aimed to assess the impact of a healthy lifestyle community-based trial on salt intake and blood pressure among a representative sample of normotensive Iranian adults. **Materials and Methods:** We compared the data for salt intake, urinary sodium levels and blood pressure from three cross-sectional surveys in time points of 1999, 2001-2002 (beginning of the community interventions), and 2007 (after the community trial) for normotensive adult population of Isfahan, Iran in the framework of Isfahan Healthy Heart Program. Using multi-stage cluster sampling method, one of the family members at each household was randomly selected with Iranian adult population as a target. Dietary salt intake was estimated based on 24 hour urinary sodium levels. Systolic and diastolic blood pressures were measured according to standard methods. **Results:** Dietary sodium intake and urinary sodium levels as well as systolic and diastolic blood pressure were significantly decreased during the 9-year study period. Unlike systolic and diastolic blood pressures that had a consistent decrement between 1999 and 2007, dietary sodium intake and urinary sodium levels were slightly raised from 1999 to 2000-2001 and then reduced between 2001-2 and 2007 evaluations. The same findings were reached when data were analyzed separately by gender or weight status. **Conclusions:** A lifestyle community trial was effective in controlling the escalating trend of blood pressure and salt intake in Iranian population. It can be considered as a model to be adopted in other developing countries.

Key words: Blood Pressure, Salt, Adult, Urine, Lifestyle

INTRODUCTION

The importance of managing hypertension, as a great public health challenge, for reducing cardio- and cerebro-vascular mortality and morbidity is well-established. This condition is of special concern in developing countries facing an epidemic of chronic non-communicable diseases with higher reported incidence of risk factors and their inappropriate control.[1]

In this way, high daily sodium intake has been known as a major risk profile and its decrease has a pivotal role in risk reduction. A decrease in salt consumption of 3 gram/day would result in a reduction in blood pressure, which in turn would lead to a reduction of 22% and 16% in stroke and ischemic heart disease deaths, respectively.[2,3] Published data from the two large international surveys, INTERSALT and INTERMAP, have shown that dietary sodium intakes of most adult population in developing world are almost 5 to 10 times of their requirement; such that dietary intakes as high as 200 mmol/day has been reported in some Asian countries.[4] The detrimental effects of high sodium intake on human health are well-known and the role of healthy low-salt diet and low sodium consumption on regulating arterial pressure level is well documented.[5] It has been demonstrated that reducing sodium intake from a high level of 150 mmol/day to an intermediate level of 100 mmol/day or a low level of 65 mmol/day would result in a stepwise reduction in blood pressure.[6]

Contrary to these well-established facts, some other studies have documented that variation in dietary

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sodium intake over the usual range may have negligible role in blood pressure regulation at population level.[7] It has been indicated that only one-third of normotensive individuals and half of hypertensive patients are salt-sensitiv.[8] Some meta-analyses and systematic reviews on the effects of dietary sodium reduction on blood pressure revealed minimal reductions in blood pressure without any relationship between the extent of decrease in sodium intake/excretion and the blood pressure.[9-11] Others have demonstrated that interventions in normotensive persons have small blood pressure effects without any significant effects on cardiovascular outcomes.[12,13]

Even though studies conducted in Western countries have identified a variety of ethnic and environmental factors modulating the effects of dietary sodium on blood pressure, such experience is scarce in other populations. To the best of our knowledge, no previous population-based data is yet reported from the Eastern Mediterranean region (EMR) in this regard. The current study aimed to assess the changes in salt intake and in blood pressure in population-based samples of normotensive individuals before and after a 6-year-community-based healthy lifestyle trial in Iran.

METHODS

Subjects: The current study has been performed in the framework of a large community-based trial entitled Isfahan Healthy Heart Program (IHHP); its methodology and sampling procedure has been described elsewhere in more detail.[14,15] As an action-oriented demonstration program, it targeted the general population, and aimed to promote healthy lifestyle behaviors, and ultimately to prevent chronic diseases. It integrated interventions and policies to reduce the major determinants of chronic diseases including unhealthy nutrition, smoking, physical inactivity and stress.[14,15] A summary of interventions is presented in Appendix1. External evaluation was undertaken by the university and international experts for both the implementation of interventions and the research components of the program; the report was submitted to the university officials and the WHO office in Iran (http://ihhp.ir/IHHP/display.aspxid=1656).

In the current study, the effects of the program were assessed on salt intake and blood pressure in repeated cross-sectional surveys among normotensive population. We used data from the year 1999 as the situation analysis of the community, data from the time point of 2001-2002 as the baseline information (before the community trial) and data from the year 2007 as the information after the trial.

A given number of normotensive adult population (independent sample surveys) from among the whole-community residents of Isfahan, the second largest city in Iran, were randomly selected by multi-stage cluster sampling method in each time point (Table 1). At each household, one of the family members was randomly selected and after explanation of the purposes of the research, s/he was invited to participate in the study. Informed written consent was provided by each participant. Individuals with bleeding disorders, mental retardation, pregnant women, history of high blood pressure, diabetes mellitus, diabetes insipidus and renal disorders, those on diuretic treatment and individuals with specific dietary patterns were not included in the current study. The project received ethical approval from the Research Committee of the Isfahan Cardiovascular Research Institute (ICRI), a collaborating center of the World Health Organization (WHO), and affiliated to Isfahan University of Medical Sciences.

Methods: All participants were invited to the survey centers for physical examination. They have also received required information about 24 hour urine sample collection. A team of trained physicians and nurses conducted primary evaluation and the baseline data collection. General and demographic characteristics of the study participants were recorded in a questionnaire. Physical examination including measurement of weight and height was performed according to standard protocols by using standardized and zero calibrated instruments. Blood pressure was measured in duplicate in a seated position according to a standard protocol; the average of two measures of the first and fifth Korotkoff phase was recorded as final systolic and diastolic blood pressures, respectively.[16] In the second (2000-2001) and third surveys (2007), blood samples were collected in a fasting state for measuring plasma glucose levels, blood urea nitrogen (BUN), serum levels of sodium, potassium, creatinine and lipid profiles. Usual dietary intake was assessed using one-day 24-hour dietary recall and a 49-item food frequency questionnaire (FFQ). All the questionnaires were administered by trained technicians. Data on physical activity and smoking were collected using pre-tested questionnaires. Due to the underestimation of sodium intake by dietary assessment tools, we used 24-hour urinary sodium excretion as a marker of dietary intake.[17] To check the completeness of 24-hour urine samples, we measured

Table 1. Socio-demographic characteristics of individuals in the three time points

Characteristics	Years 1999-2000 (n=1059)	2001-2002 (n=374)	2007 (n=806)	p-value
Male gender	446 (42.2)	180 (48.1)	350 (43.4)	0.13[1]
Age (year)	37.97±12.22	36.34±13.14	36.77±12.31	0.04[2]
Age group(year)				
19 – 24 y	157 (14.8)	86 (23.1)	127 (16.2)	
25 – 54 y	770 (72.7)	248 (66.5)	580 (74)	<0.01[1]
>=55 y	132 (12.5)	39 (10.5)	77 (9.8)	
BMI (Kg/m^2)	25.19±4.36	25.04±4.58	25.35±4.31	0.51[2]
BMI > 25 (Kg/m^2)	522 (49.9)	177 (47.7)	400 (52.1)	0.36[1]
Smoking status				
Current	63 (6.0)	54 (14.5)	74 (9.6)	<0.01[1]
Past and never	989 (94)	319 (85.5)	698 (90.4)	
Education level				
Illiterate	144 (13.6)	31 (8.6)	47 (6.0)	
Primary school	310 (29.3)	94 (26)	155 (19.8)	
Middle school	227 (21.5)	61 (16.9)	146 (18.7)	<0.01[1]
High school and diploma	254 (24)	120 (33.1)	265 (33.9)	
College degree	122(11.5)	56(15.5)	169(21.6)	
Occupation				
Working	352 (34.7)	148 (39.6)	302 (38.5)	
Housewife	552 (54.4)	188 (50.3)	383 (48.9)	0.17[1]
Retired	49 (4.8)	22 (5.9)	48 (6.1)	
Unemployed	61 (6.0)	16 (4.3)	51 (6.5)	

[1] P-value obtained from chi-square test.
[2] P-value obtained from ANOVA

urinary creatinine. Individuals with incomplete urine samples were excluded from the study.

The participants received information and materials for the urine collection covering the period from 7 a.m. to 7 a.m. of the next day. Biochemical analyses were conducted in ICRC central laboratory, with adherence to national and international external quality control. For sodium (Na) and potassium (K) measurements, we used SEAC (FR20) flame spectrophotometer by Na and K SEAC standards. Autoanalyzer Hitachi 902 was used for glucose, BUN, creatinin and lipids measurements.

Statistical analysis: All statistical analyses were done when the assumptions were checked. In each time point, comparison of the continuous variables between men and women were performed by Student's t-test. The same methods were applied for comparison of these variables between obese vs. non-obese participants. Distribution of individuals in terms of categorical variables was compared using the Chi-square test. Changes in dietary salt intake, urinary sodium creatinine ratio excretion as well as systolic and diastolic blood pressure during the study period adjusted by age, education, occupation were determined by using the multivariate analysis of covariance (MANCOVA) method. We considered 2-tailed P values of less than 0.05 to be statistically significant. Analyses were conducted using SPSS statistical software version 16.0 for windows (SPSS Inc., Chicago, USA).

Results

The study population consisted of 1059 (42.2% male) in 1999, 374 (48.1% male) in 2001-2002, and 806 (43.4% male) in 2007. As presented in table 1, no significant differences were observed in terms of male to female ratio, occupational status and mean body mass index comparing the three time points. However, participants in year 1999 were slightly older, less likely to be educated and current smokers as compared with those studied in 2007.

Taking men and women together, dietary sodium intake and urinary sodium levels as well as systolic and diastolic blood pressure adjusted by age were significantly decreased during the 9-year study period (Figure 1). Unlike systolic and diastolic blood pressures that had a consistent decrement between 1999 and 2007, dietary sodium intake was slightly raised from 1999 to 2000-2001 and then reduced between 2001-2 and 2007 evaluations. The same findings were reached when data were analyzed separately by gender (Table 2) or weight status (Table 3). Changes in systolic, diastolic blood pressure and salt intake are presented

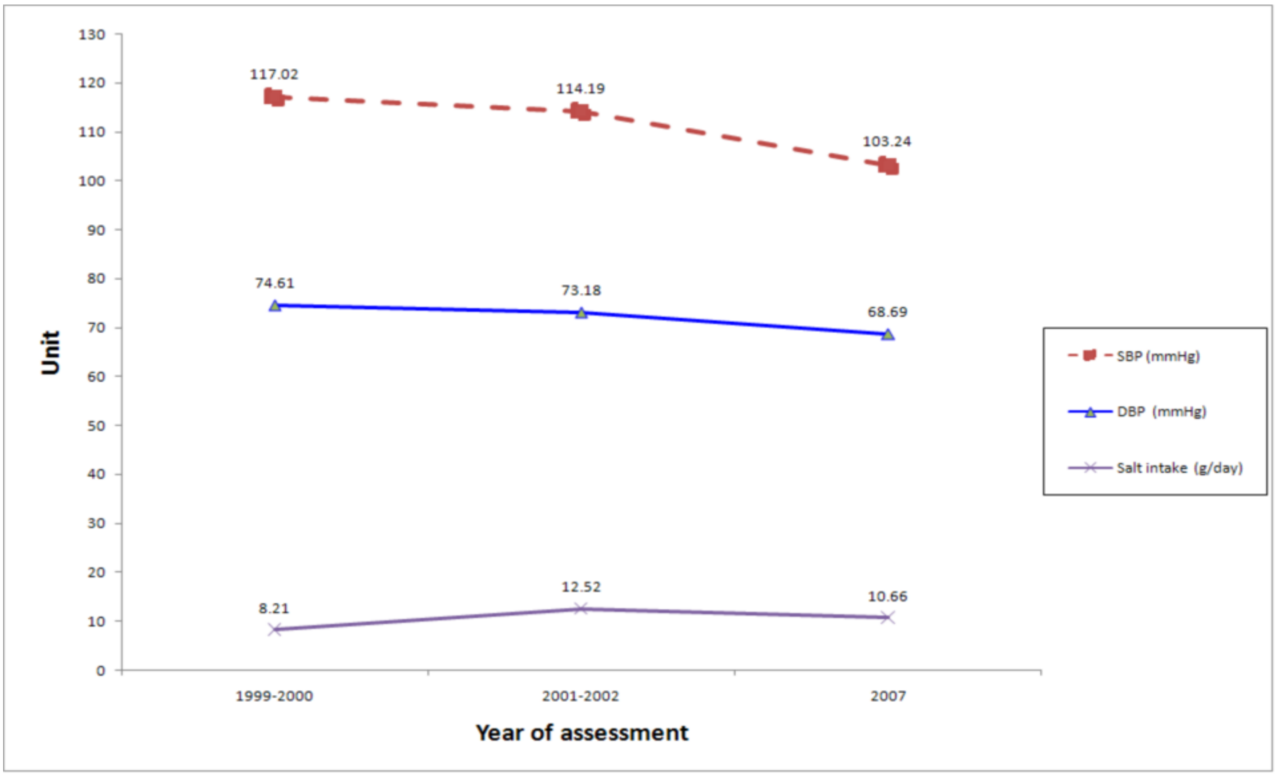

Figure 1. Changes in measured clinical and biochemical parameters during the three study time points adjusted by age (Changes of all measurements were significant; p < 0.01)

Table 2. Blood pressure and salt intake changes based on sex in the three study time points

	Years			
Characteristics	**1999-2000 (n=1059)**	**2001-2002 (n=374)**	**2007 (n=806)**	**p-value1**
Systolic blood pressure (mmHg)				
Men	118.78± 0.61	116.54±0.84	104.95± 0.63	<0.01
Women	116.35± 0.59	111.09±0.91	102.05± 0.63	<0.01
p-value[2]	<0.01	<0.01	<0.01	
Diastolic blood pressure (mmHg)				
Men	75.47± 0.49	74.56± 0.68	69.61± 0.51	<0.01
Women	73.90± 0.49	71.63± 0.76	68.34± 0.53	<0.01
p-value[2]	<0.05	<0.01	<0.05	
Salt intake (g/day)				
Men	7.59±0 .36	13.29± 0.49	11.47± 0.37	<0.01
Women	8.17± 0.31	11.49± 0.49	9.93± 0.34	<0.01
p-value[2]	>0.05	<0.01	<0.01	
Urinary Sodium Creatinine Ratio				
Men	0.16±0.005	0.19±0.007	0.13±0.005	<0.01
Women	0.15±0.005	0.19±0.007	0.15±0.005	<0.01
p-value[2]	>0.05	>0.05	<0.05	

Data are explain as Mean ± SEM
[1] P-value obtained from MANCOVA for the comparison of time-trend variations adjusted by age, education, occupation. There was a statistically significant difference between a time-trend variations on their dependent variables (SBP, DBP, Salt, Urinary Sodium Creatinine Ratio). For female F (8, 2188) = 70.77, *p* < .0001; Wilk's λ = 0.63.and For male: F (8, 1620) = 76.91, *P* < .0001; Wilk's λ = 0.53.

Table 3. Blood pressure and salt intake changes based on weight status in the three study time points

Characteristics	Years 1999-2000 (n=1059)	2001-2002 (n=374)	2007 (n=806)	p-value1
Systolic blood pressure (mmHg)				
Non-obese	115.85± 0.45	112.43 ± 0.72	99.98 ± 0.51	<0.01
Obese	119.41± 0.45	115.45 ± 0.77	106.14 ±0.49	<0.01
p-value[2]	<0.01	<0.01	<0.01	
Diastolic blood pressure (mmHg)				
Non-obese	73.61± 0.38	71.61± 0.60	66.27± 0.43	<0.01
Obese	75.73± 0.36	74.54± 0.62	70.72± 0.40	<0.01
p-value[2]	<0.01	<0.01	<0.01	
Salt intake (g/day)				
Non-obese	7.69± 0.23	11.59 ± 0.36	9.36 ± 0.26	<0.01
Obese	8.22 ± 0.27	13.55 ± 0.46	11.93 ± 0.29	<0.01
p-value[2]	>0.05	<0.01	<0.01	
Urinary Sodium Creatinine Ratio				
Non-obese	0.16±0.004	0.19±0.006	0.13±0.004	<0.01
Obese	0.16±0.004	0.19±0.006	0.14±0.004	<0.01
p-value[2]	>0.05	>0.05	>0.05	

Data are explain as Mean ± SEM
[1] p-value obtained from MANCOVA for the comparison of time-trend variations adjusted by age. There was a statistically significant difference between a time-trend variations on their dependent variables (SBP, DBP, Salt, Urinary Sodium Creatinine Ratio). For non-obese: $F (8, 1912) = 88.11$, $p < .0001$; Wilk's $\lambda = 0.53$.and for obese: $F (8, 1934) = 72.15$, $p < .0001$; Wilk's $\lambda = 0.59$.

after adjusting for age, education, occupation in men and women (Table 2). Furtherer smoking was adjusted in men which yield to no significant changes. (Data not shown)

In the three year points, both systolic and diastolic blood pressures and salt intake were significantly higher in men than in women, however the salt intake was higher in women than men in 1999 but this change was non-significant.

DISCUSSION

We found that the community-based lifestyle intervention program among normotensive adult population of a developing country, Iran, has been resulted in a lower salt intake and decreased systolic and diastolic blood pressure. To the best of our knowledge, the current study is the first report on the impact of a community-based trial on blood pressure and changes in salt intake not only in Iran, but also in the Eastern Mediterranean Region. This study is also among the first studies conducted in developing countries. It demonstrated that similar to most countries, salt intake and blood pressure were increasing in our population, and a lifestyle program comprising preventive and promotional activities was effective in controlling this escalating trend.

These findings can be assessed in the two time periods. In the first study period from 1999 to 2001-2002, the increase in salt intake might be due to the nutrition transition and tendency to a Western diet, particularly fast foods, salty snacks and processed foods. The considerable decline in salt intake and in turn in blood pressure from 2000-2001 to 2007 might reflect the effectiveness of the comprehensive interventions of IHHP incorporating a variety of activities.

This study also revealed that although both systolic and diastolic blood pressures were gradually decreasing within the period of time from 1999 to 2007, changes in salt intake, as reflected by urinary sodium levels had a crescendo-decrescendo pattern. This finding may be explained by the rapid rise in salt intake in our community that has been halted by the effect of the IHHP intervention activities. Furthermore, smoking habits have decreased from 1999 to 2007 which may explain the larger reduction in BP levels, however the change in blood pressure or salt intake didn’t differ after smoking adjustment. It seems that the salt consumption estimated from the 24-hour urine sodium excretion among our participants is partially higher than the current recommendations from international associations,[18] but the percentage of individuals classified as hypertensive reached lower levels after the years of beginning the trial. Furthermore, the smaller decrease in salt intake compared to BP decrease can be explained by the fact that considerable higher increase of urinary creatinine in comparison to urinary sodium can result in decreasing quintile of urinary sodium/creatinine ratio[19] and therefore decreasing blood pressure. In addition, although many trials have shown that changes in sodium intake and blood pressure are in the same direction, such association has been less consistent at population level.[20,21] Furthermore, some high quality observations have revealed only a weak relationship between sodium intake/excretion and blood pressure in the general population without association between the magnitude of reduction in sodium intake/excretion and the blood pressure effect.[22] Salt sensitivity and resistance have a large variety of determinants, including genetic factors, race/ethnicity, age, body mass index and diet in terms of overall diet quality and macro -and micronutrient content.[23,24] However none of them could provide an adequate explanation for the salt sensitivity of the blood pressure.

The larger decline in mean blood pressure than salt intake in the studied population might be related to the accomplishment of integrated and comprehensive interventions of this community trial in various items as increase of the awareness, treatment and control rates of hypertension, partial reduction in the obesity rate and improvement in overall dietary habits. As potassium intake is known to induce suppression of the salt sensitivity of the blood pressure, one of the most important factors might be the increase in dietary intake of potassium-rich foods as legumes, fruit and vegetables by our population after the dietary interventions of this community trial.[25,26]

Reported ranges of daily sodium intake in different nations have large variations. Based on some recent meta-analysis, reported salt intake varied from 1 mmol/day among the Yanomamo Indians of Brazil to 385 mmol/day in Korea and the Bahamas.[27,28] Taken into account that salt intake is considered as an independent cardiovascular risk factor and that salt loading may have a blood pressure-independent effect on vascular wall function,[29] more intensive interventions are necessary for reducing salt intake at the population level. Because of blood pressure-independent effects of salt intake on cardiovascular diseases, decreasing salt intake shall be considered as a public health priority in communities facing nutrition transition.

Several limitations must be taken into account in the interpretation of our findings. First is the short duration of the intervention. Therefore, it is not clear to what extent the effect of intervention of dietary salt intake and blood pressure could be sustained. Furthermore, it is not clear if these improvements in dietary salt intake and blood pressure can be translated into the reduction in cardiovascular mortality. However, a modest reduction in blood pressure at a population level has been indicated to translate into great reductions in deaths from stroke and coronary heart diseas.[30] As IHHP consisted of multiple interventions that were implemented simultaneously, therefore we cannot assess which component of our lifestyle intervention program was more beneficial in reducing salt intake and blood pressure. Furthermore, this was not the aim of this program which has been designed as a composite approach of various components targeting healthy lifestyle. This study has also several strengths. To the best of our knowledge, this study is among the first investigations assessing the effect of community-based lifestyle interventions on blood pressure in a developing country. Enrollment of an appropriate control group, which was in a large distance from the intervention area, is also a strength of our study.

In conclusion, the present study documented a successful experience of a community-based trial in concurrent reducing blood pressures as well as salt intake in a population experiencing increase in salt intake during the years before the trial. The community participatory approach of this trial might be adopted in other developing countries.

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