Effectiveness of Sodium Reduction Program on Urine Sodium Output among a Community Population: Cohort Study

Phatcharin Winyangkul[1], Lakkana Thaikruea [2], Penprapa Siviroj[3], Sakda Pruenglampoo [4]

[1]Ph.D. Student, [2]Professor Dr. M.D., [3]Associate Professor Dr. and Head, Department of Community Medicine, Faculty of Medicine and [4]Dr. Research Institute for Health Sciences, Chiang Mai University, Chiang Mai University 50200, Thailand

Abstract

Aim and Objective: The effect of reducing sodium consumption has been examined in sodium reduction programs that were designed to fit each area, using individual level intervention, but some outcomes were inconclusive. This 6-month study aimed to reveal effects of the combined individual-family-community program for reducing the intake of sodium and its content in urine in a community population.

Materials and Method: This cohort study recruited 127 participants from the community. All of them completed a 3-month individual-family-community program within the 6-month period of the study. Outcome measures assessed at baseline and the 1st and 3rd month of the program, and 6th month of the study, showed sodium content in first-morning urine, blood pressure, risk of excessive sodium intake, knowledge and self-efficacy.

Result: The participants showed significant improvement in all outcomes at month 1 ($p<0.05$) when compared to baseline of the program. Knowledge was the only outcome that showed significance at month 3 of the program and 6 of the study period. The combined individual-family-community program was effective in the reduction of sodium output in urine and blood pressure, and increase of knowledge and self-efficacy in the community.

***Keywords**: sodium consumption, sodium reduce program, community, knowledge, self-efficacy-*

Introduction

Non-communicable diseases (NCDs) are a major cause of death worldwide [1]. It is estimated that they can lead to 49% of coronary heart disease [2]. Increased blood pressure level and hypertension are important risk factors for cardiovascular disease. High blood pressure can cause stroke [2], which is associated with sodium intake. The World Health Organization (WHO) determined that sodium salt reduction is one of nine global targets for controlling NCDs [3], since the reduction of sodium intake could reduce blood pressure levels [4, 5]. Systematic reviews also showed that reducing sodium intake could reduce blood pressure and risk of cardiovascular disease [6-7]. Furthermore, the WHO is concerned about these significant problems and has set a national goal of reducing sodium intake in the global population by 30% by 2023[8].

Previous studies have investigated the effect of programs for reducing sodium intake in normal populations. These programs had interventions that consisted of self-management, self-efficacy and self-monitoring. [9-11]. Although these studies showed good outcomes in reducing blood pressure and sodium intake after intervention, and the programs were designed to fit each area and use individual level intervention, some outcomes were inconclusive. Moreover, interventions such as educational programs and family and community level intervention were used rarely in previous studies. Hence, implementing the same programs for reducing

Corresponding author:
Lakkana Thaikruea
Lsayam@yahoo.com;
Tel.: +66-08-6920-4243

sodium intake may not be utilized wholly in the general population.

Therefore, this study aimed to research effects of the combined individual-family-community program for the reduction of sodium intake and content in urine, blood pressure and risk of excessive sodium intake, and increase of knowledge and self-efficacy in the community.

Materials and Methods

Study design and Study population

This was a cohort study. A total of 127 normally healthy participants were recruited from a Chinese-Haw tribe in Pa Tueng, Mae Chan district, Chiang Rai province between January and December 2017. The sample size was calculated from the n4Studies app [14]. The inclusion criteria included participants with a urine sodium output of more than 2,400 mg/day and aged 30 years or older. The exclusion criteria included those who were diagnosed with hypertension, and heart and kidney disease. The one group pre-posttest design, derived from analysis of sodium content from first-morning urine, was examined by the Atomic Absorption Spectrophotometer (AAS) method, before using the formula for calculating 24-h Na excretion (mmol/day) [15].

Outcome measurements

Outcome measurements were assessed at baseline and the 1st and 3rd month of the program and 6th month of the study.

1. Self-efficacy [16] was assessed by a self-confidence questionnaire that determined the

ability of the participants to practice sodium reduction. Its validity and reliability was 0.73 and 0.83, respectively. Ten items had a core range of 0-10 points, with a cut-off point at 72 points.

2. The risk of excessive sodium intake was assessed by the Food Frequency

Questionnaire (FFQ) [17], with its validity and reliability valued at 0.76 and 0.80, respectively.

3. There were 10 questions for assessing dietary consumption over the previous 7 days. Original Bloom's cut-off points were used for assessing sodium consumption [18], with their validity and reliability being 0.76 and 0.89, respectively. Knowledge scores ranged from 1 to 15 points and were interpreted into two levels as follows: 1) Pass means total score was at least 50% or 8–15 points; and 2) not pass means total score of less than 50% or 0–7 points.

4. The sodium content in urine was assessed by the

AAS method. First-morning urine samples were used in this method for calculating sodium intake. They were kept in a freezer at minus 80 degrees Celsius before being sent to a standard laboratory. The value of urine sodium and creatinine was used in the formula for calculating sodium intake [15].

5. Blood pressure was measured by a sphygmomanometer (Terumo brand, serial number

ES-P370, Terumo Company Ltd., Japan).

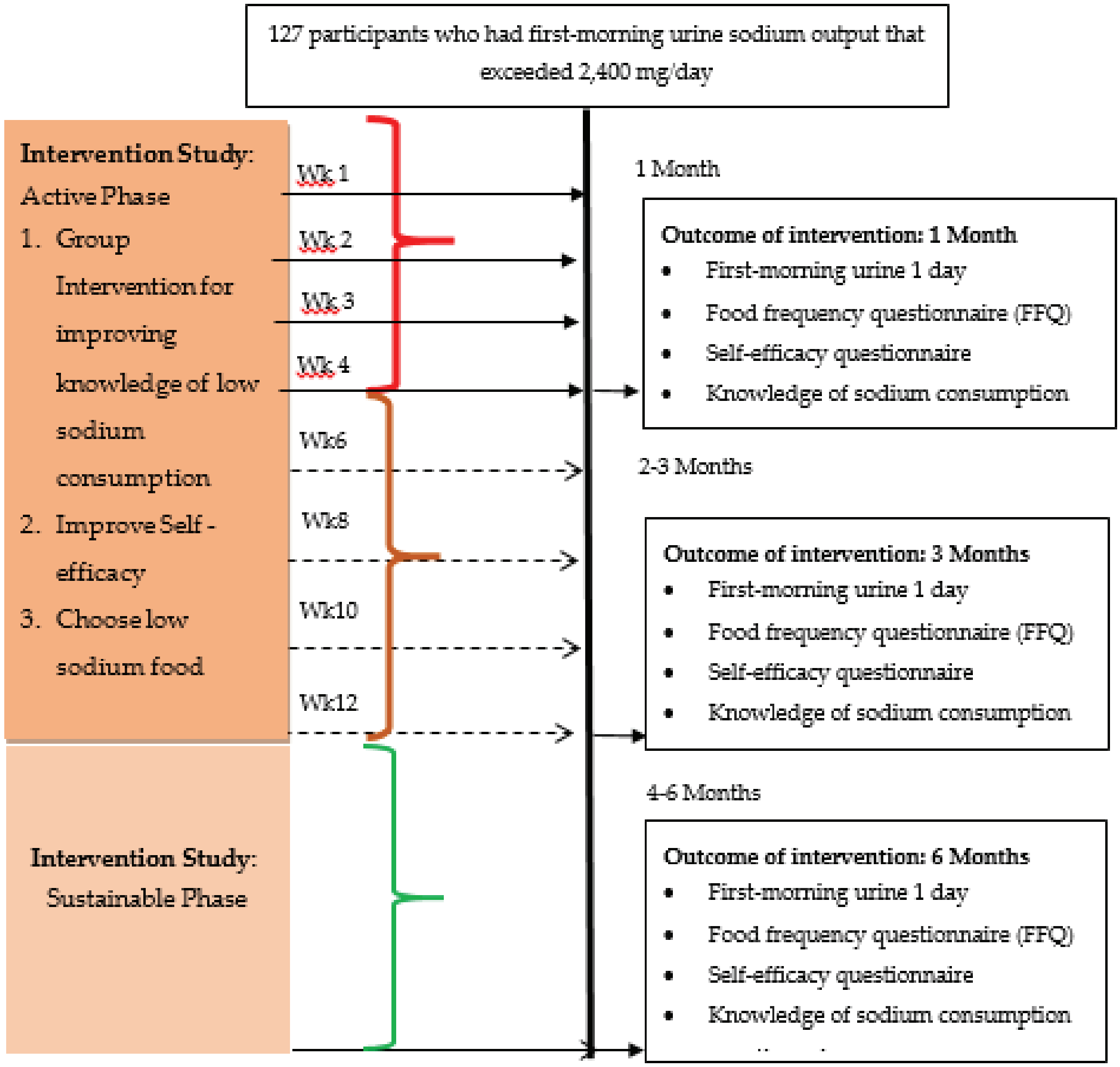

Figure 1: Flow chart of research intervention.

Intervention

The participants received the program for reducing sodium intake, which comprised individual, family and community level intervention.

Individual level: One hundred and twenty seven participants attended educational classes (knowledge and self-efficacy) once a week in the 1st month and every other week in the 2nd and 3rd month of the program.

Family level: Family members who cooked for the participants were invited to take part in a cooking training class for the first time in the 1st month of the program.

Community level: The village headman announced basic knowledge of sodium and health once a week in the 1st month and every other week during the 2nd and 3rd month of the program.

None of the participants received any intervention after the 3rd month of the program (total program duration = 3 months).

Data Analysis

Data were analyzed using SPSS version 22 (SPSS

Inc., IBM Singapore Pte. Ltd., Changi Business Park Central 1, Singapore) [19]. The results were analyzed as mean, standard deviation (SD), median (Minimum-maximum), percentage and proportion. The paired t-test was used to compare each outcome within a group. A p-value of <0.05 was set as the level of statistical significance.

Results

A total of 127 participants were recruited into this study and assessed at baseline and the 1st and 3rd month of the program and 6th month of the study. All of them completed the study at month 6 and none of them dropped out. The mean age of the participants was 51.3±10.9 years and the majority were female (68.5%); 85.0% were married; 66.1% were agricultural workers; 86.6% were uneducated; and 82.7% had inadequate income and were unable to save money. The median of sodium in urine was 3,515.4 mg/day, with that of creatinine in urine valued at 95.56 mg/dl.

Table 1 shows proportion of the intervention result in reducing sodium intake by using the cut-off criteria in urine values of more than 2,400 mg/day. In almost all of the 127 cases, the variables were found to have decreased from the baseline data, except for self-efficacy that was found to decrease in the first month compared to baseline. Self-efficacy increased in value and then returned to a reduced value in the following measurements.

Table 1 Proportion of the intervention result in reducing sodium intake (n=127 cases)

Variables		Baseline n (%)	Follow-up		
			1 Month n (%)	3 Month n (%)	6 Month n (%)
Urine Sodium Cut off 2,400 mg/day					
	< 2,400 mg/day	30 (19.10)	51 (32.50)	29 (18.50)	29 (18.50)
	≥ 2,400 mg/day	127 (80.90)	106 (67.50)	128 (81.50)	128 (81.50)
2. Systolic Blood Pressure (SBP) cut off ≥ 140 mm.Hg					
	< 140 mm.Hg	91(71.70)	124(97.60)	88(69.30)	97(76.40)
	≥ 140 mm.Hg	36(28.30)	3(2.40)	39(30.70)	30(23.60)
3. Diastolic Blood Pressure (DBP) cut off ≥ 90 mm.Hg					
	< 90 mm.Hg	114(89.80)	126(99.20)	115(90.60)	115(90.60)
	≥ 90 mm.Hg	13(10.20)	1(0.80)	12(9.40)	12(9.40)
4. FFQ Score					
	Low Risk (0 – 3)	80(63.00)	85(66.90)	104(81.90)	104(81.90)
	Middle Risk (4 – 7)	36(28.30)	27(21.30)	21(16.50)	21(16.50)
	High Risk (8 – 10)	11(8.70)	15(11.80)	2(1.60)	2(1.60)
5. Knowledge Score					
	Pass ≥ 8 score	42(33.10)	92(72.40)	107(84.30)	96(75.60)
	Not pass < 8 score	85(66.90)	35(7.60)	20(15.70)	31(24.40)
6. Self – Efficacy (Median score 72.00, rang minimum – maximum score 18 - 100					
	At least 72.00	58(45.70)	53(41.70)	61(48.00)	95(74.80)
	Less than 72.00	69(54.30)	74(58.30)	66(52.00)	32(25.20)

Table 2 presents effectiveness of the intervention in reducing sodium intake and comparison of mean difference with baseline.

Sodium intake, as measured by AAS (first-morning urine sodium content of more than 2,400 mg/day), decreased at month 1 (-154.61), but rapidly increased at month 3 of the program (422.82) and 6 (577.15) of the study.

Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP) levels were -9.19 and -6.40, 5.12 and -0.52, and 0.40 and -1.78 at the 1^{st} and 3^{rd} month of the program and 6^{th} month of the study, respectively.

The average knowledge score measured by sodium consumption was found to increase to 3.08, 4.22 and 3.42 in the 1^{st} and 3^{rd} month of the program and 6^{th} month of the study, respectively.

Table 2 Effectiveness of intervention in reducing sodium intake and comparison of mean difference with baseline (n=127 cases)

Variables	Baseline Mean (±S.D.)	Follow-up								
		1 Month			3 Months			6 Months		
1. Urine Sodium, mg/day		Mean (±S.D.)	Δ Mean (±SD)	P value	Mean (±S.D.)	Δ Mean (±SD)	P value	Mean (±S.D.)	Δ Mean (±SD)	P value
	3515.43 (±1065.77)	3360.82 (±1427.28)	-154.61 (±137.60)	0.26	3938.25 (±2008.91)	422.82 (±188.34)	0.03*	4092.58 (±2258.05)	577.15 (±220.84)	0.01**
2. SBP, Mean (±S.D.)										
	132.83 (±20.75)	123.63 (±11.99)	-9.19 (±22.81)	0.00**	137.83 (±18.15)	5.12 (±29.61)	0.50	133.24 (±18.32)	0.40 (±20.07)	0.81
3. DBP, Mean (±S.D.)										
	76.14 (10.72)	69.74 (±9.17)	-6.40 (±14.86)	0.00**	75.62 (±9.93)	-0.52 (±13.95)	0.67	74.36 (±11.62)	-1.78 (±11.20)	0.07
4. Knowledge Score (±S.D.)										
	7.92 (±2.14)	11.00 (±3.09)	3.08 (±3.61)	0.00**	12.14 (±2.92)	4.22 (±3.54)	0.00**	11.34 (±3.13)	3.42 (±3.30)	0.00**

Discussion

The participants of this research were selected from those having first-morning urine sodium samples of more than 2,400 mg/day, and most of them were female, married, lacked education, and had insufficient income. Nearly all of the participants cooked for themselves and their family.

The mean difference of knowledge score continued to increase throughout the research period. This was consistent with Lara Nasreddine et al.[24], who found the majority of their subjects had knowledge that high dietary salt might worsen health status. However, the findings of Leila Cheikh Ismail et al.[25] indicated low salt-related knowledge scores among their students.

If people could reduce sodium consumption by at least 30 percent, they would reduce morbidity and mortality [17]. This study found that the sodium reduction program could reduce urine sodium output by 32.5 percent from baseline, which is in line with previousstudies [9-11].

This research revealed that the mean difference between SBP and DBP levels were decreased. At the same time, previous studies showed evidence that substantial statistical heterogeneity of SBP and DBP were reduced in all intervention arms – normotensives [9-11].

The risk of excessive sodium intake, as measured by the FFQ scores, showed decreased score in high- and moderate-risk groups, but increased score in low-risk groups at the 1st and 3rd month of the program and 6th month of the study. Similarly, Lara Nasreddine et al.[24] found a high proportion of their participants reporting that they generally checked information on food labels, which affected their purchasing decisions. However, Durreajam Khokhar et al.[26] found that about half of all parents in their study reported adding salt to their own food at the table, while about one third reported adding salt to the food of their child/children.

Self-efficacy score at baseline increased in the low self-efficacy group at the 1st and 3rd month of the program and 6th month of this study, which showed that the program could improve self-efficacy and be maintained throughout the 6-month period. Similar studies by Lu Hu et al. [27], found that interaction between dietary self-efficacy and intervention had impact on the changes in dietary sodium density; and So-hyun Ahn et al. [28], found that self-efficacy was the primary resource for stronger related intention to perform healthy eating practices than expected.

The strength of this study was the combination of 3 intervention levels (individuals, family and community), which could reduce sodium intake and sustain knowledge of sodium consumption. This study found that key success at the family level was housewives who cook for themselves and family at home. This was the key factor in changing cooking habits and reducing sodium ingredients in food for the family. However, the limitation of this study was no comparison group in the program. Therefore, it is suggested that further study should be designed to cover case and control for comparison, consistency and sustainability.

Conclusion

This program could be applied and extended to other groups who encounter sodium consumption problems beyond the standard criteria. The effects of this research model in reducing sodium intake, are seen through the effective frequency of activities that stimulate knowledge, self-efficacy and regulation of salty diets. Therefore, health volunteers who support health workers lead to sustainability.

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Conflicts of Interest: The authors declare no conflict of interest.

Ethical clearance: This study protocol was approved by the Committee of Research Ethics in the Faculty of Medicine, Chiang Mai University (Study Code No. COM-2559-03677/Research ID: 3677)

References

1. World Health Organisation, NONCOMMUNICABLE DISEASES COUNTRY PROFILES 2018; 2018 [cited 2019 Setp 20] *Available from:* https://www.who.int/nmh/publications/ncd-profiles-2018/en/
2. WHO publishes definitive atlas on global heart disease and stroke epidemic. Indian J Med Sci, 2004. 58(9): p. 405-6.
3. World Health Organisation. Global action plan for the prevention and control of non-communicable disease 2013 - 2020. 2013 [cited 2018 May 10]; Available from: https://apps.who.int/iris/bitstream/handle/10665/94384/9789241506236_eng.pdf;jsessionid= 37E9E248FAE7372C3FFE22C0DC77FE16? sequence=1.
4. Caldeira, D., A. Vaz-Carneiro, and J. Costa, [What is the benefit of salt reduction on blood pressure? Assessment of the Cochrane Review: Effect of longer-term modest salt reduction on blood

pressure. He FJ, Li J, Macgregor GA. Cochrane Database Syst Rev. 2013 Apr 30;4:CD004937]. Acta Med Port, 2013. 26(5): p. 490-2.

5. He, F.J., J. Li, and G.A. Macgregor, Effect of longer term modest salt reduction on blood pressure: Cochrane systematic review and meta-analysis of randomised trials. BMJ, 2013. 346: p. f1325.

6. Lewington S, Clarke R, Qizilbash N, et al. Age-specific relevance of usual blood pressure to vascular mortality: a meta-analysis of individual data for one million adults in 61 prospective studies. Lancet. 2002; 360: 1903-13.

7. He FJ, MacGregor GA. Effect of modest salt reduction on blood pressure: a meta-analysis of randomized trials. Implications for public health. Journal of human hypertension. 2002; 16: 761-70.

8. Department of Disease Control, Strategy for Reducing Salt and Sodium Consumption in Thailand 2016-2025, ed. 1. 2016, Ministry of Public Health: The Bureau of Non-Communicable Diseases, Department of Disease Control.

9 Cook NR, Cutler JA, Obarzanek E, et al. Long term effects of dietary sodium reduction on cardiovascular disease outcomes: observational follow-up of the trials of hypertension prevention (TOHP). Bmj. 2007; 334: 885-8.

10 Kumanyika SK, Cook NR, Cutler JA, et al. Sodium reduction for hypertension prevention in overweight adults: further results from the Trials of Hypertension Prevention Phase II. Journal of human hypertension. 2005; 19: 33-45.

11. Whelton PK, Appel LJ, Espeland MA, et al. Sodium reduction and weight loss in the treatment of hypertension in older persons: a randomized controlled trial of nonpharmacologic interventions in the elderly (TONE). TONE Collaborative Research Group. Jama. 1998; 279: 839-46.

12. Salty intake reduction network. Campaign to drive campaign to reduce salt consumption (sodium) in Thailand. 2015 [cited 2015.

13. Winyangkul P, Thaikruea L, Siviroj P, Pruenglampoo S. Prevalence and Potential Risk Factors Associated with High Sodium : Intake among Chinese-Haw Tribal in the Rural Area of Chiang Rai Province, Northern Thailand. The Open Public Health Journal. 2020; 13: p. 22 - 29.

14. Ngamjarus, C., et al., Enhancement of Learning on Sample Size Calculation with a Smartphone Application: A Cluster-Randomized Controlled Trial. Southeast Asian J Trop Med Public Health, 2017. 48(1): p. 240-52.

15. Ngata, C., et al., Sodium intake and risk of death from stroke in japanese men and women. Stroke, 2004. 35(7): p1543-7.

16. Albert Bandura, Self-Efficacy: The Exercise of Control. 1997, New York: W.H. Freeman and Company; 1997.

17. Health Education Division. Health Behavior Monitoring System to Modify Risk Behavior of Normal/Risk/Diabetic Mellitus Hypertension in Thailand: Policy for Practice for Primary Care Facilities. 2013 [cited 2013.

18. Bloom BS, Taxonomy Education. 1956, New York: David Mckay.

19. IBM Corp, IBM SPSS statistics for windows. 2013, IBM Corperation.

20. Bingham S, The dietary assessment of individuals; methods, accuracy, new techniques and recommendations. Nutr Abstr Rev A Hum Exp, 1987. 57: p. 705-42.

21. Bates CJ TDMB, N.M., Biochemical markers of nutrient intake, Design Concepts in Nutritional Epidemiology. 1991, OxfordOxford University

22. Hunter D., W.W., Biochemical indicators of dietary intake, Nutrional Epidemiology, ed. nd. 1998, OxfordOxford University.

23. Pietinen, P.I., et al., Studies in community nutrition: estimation of sodium output. Prev Med, 1976. 5(3): p. 400-7.

24. Nasreddine L., et al., Consumer Knowledge, Attitudes and Salt-Related Behavior in the Middle-East: The Case of Lebanon. Nutrients,2014. 6: p 5079-5102; doi:10.3390/nu6115079

25. Ismail LC., et al., Knowledge, Attitude, and Practice on Salt and Assessment of Dietary Salt and Fat Intake among University of Sharjah Students. Nutrients, 2019. 11, 941; doi:10.3390/nu11050941

26. Khokhar D et al., Knowledge and Attitudes Are Related to Selected Salt-Specific Behaviours among Australian Parents. Nutrients, 2018. 10, 720; doi:10.3390/nu10060720

27. Hu et al., Determinants and the Role of Self-Efficacy in a SodiumReduction Trial in Hemodialysis patients. J Ren Nutr . 2019 July ; 29(4): 328–332. doi:10.1053/j.jrn.2018.10.006.

28. Ahn et al., Stages of Behavioral Change for Reducing Sodium Intake in Korean Consumers: Comparison of Characteristics Based on Social Cognitive Theory. Nutrients 2017, 9, 808; doi:10.3390/nu9080808

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