제25차 대한당뇨병학회 춘계학술대회

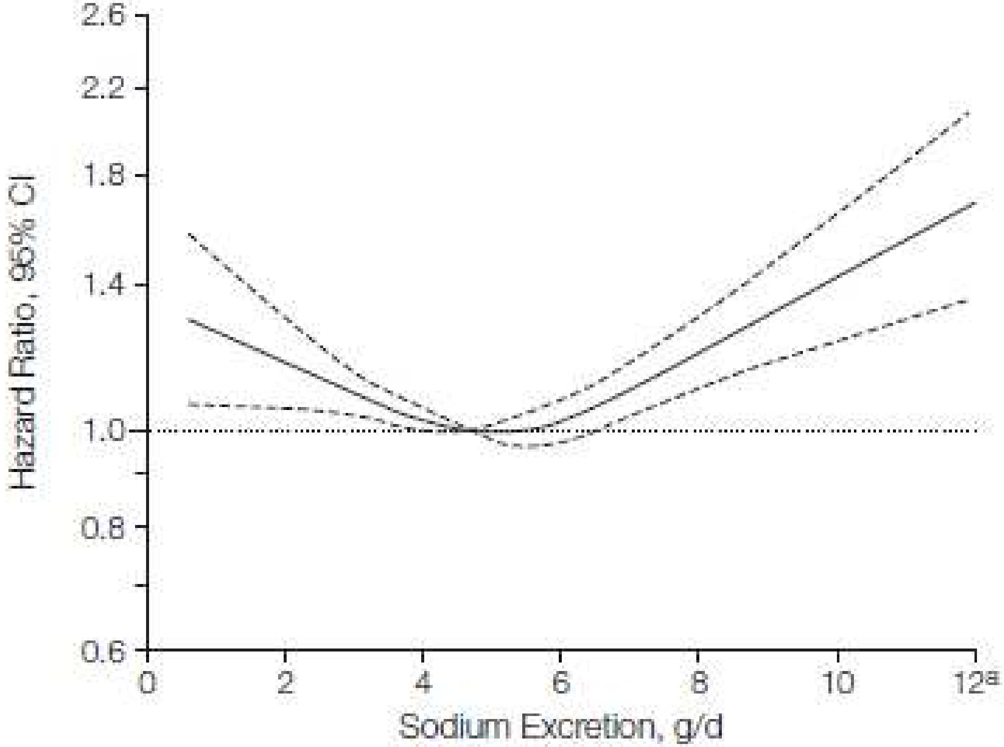
Epidemiologic Evidence of Sodium Intake with CV risk and sodium J curve as new explanation

2012.05. 12

동아의대 예방의학교실

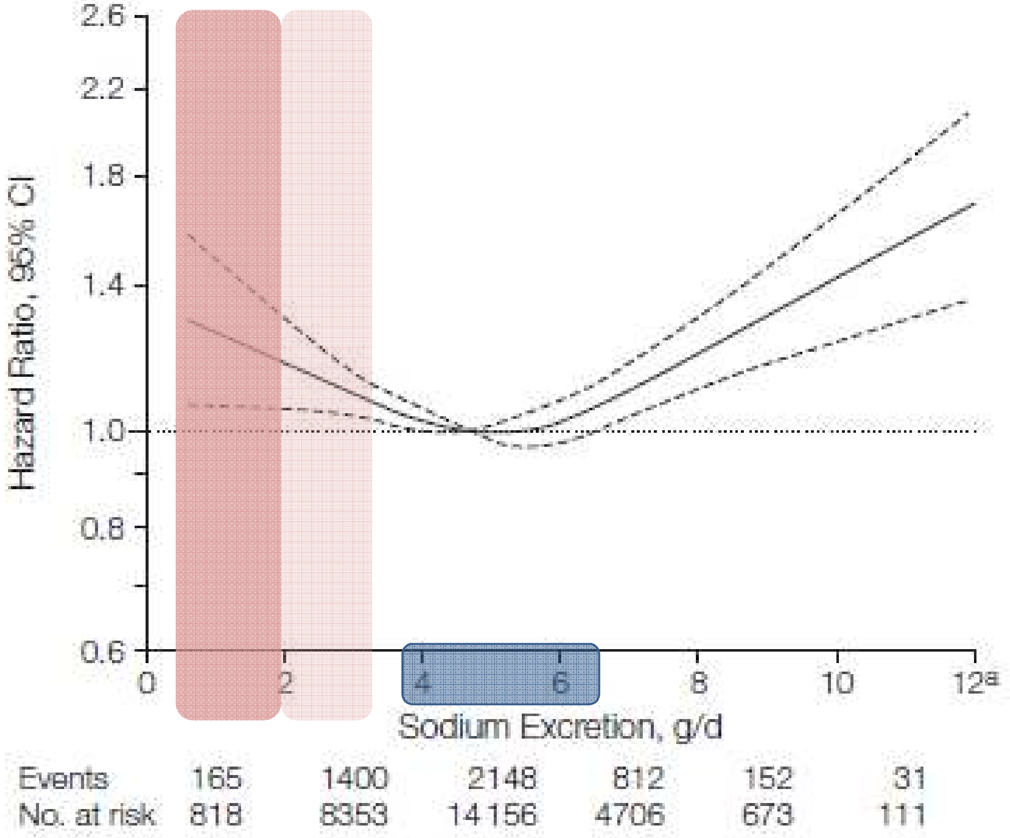
김유미

염분섭취의 J 곡선



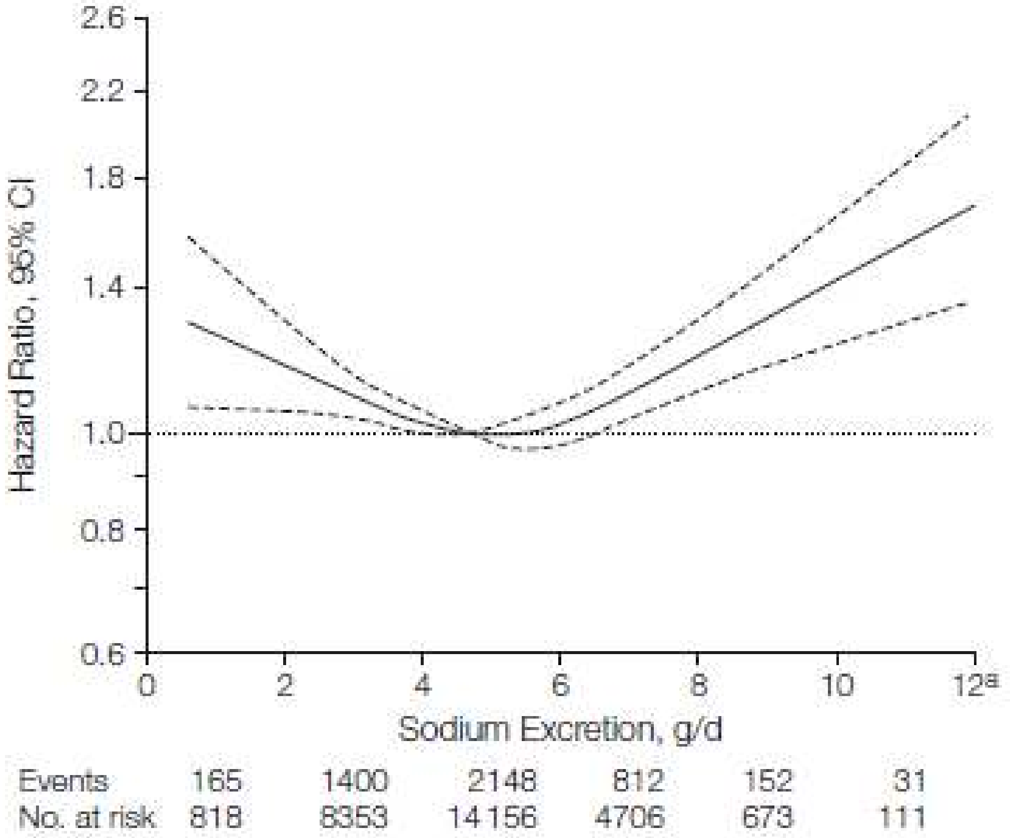
Events	165	1400	2148	812	152	31
No. at risk	818	8353	14 156	4706	673	111

O'Donnell M. J. et al. Urinary Sodium and Potassium Excretion and Risk of Cardiovascular Events JAMA. 2011;306(20):2229-2238



Equivelence of soduim excretion/salt intake: 4-5.99 =10-14.9 (g/day)

O'Donnell M. J. et al. Urinary Sodium and Potassium Excretion and Risk of Cardiovascular Events JAMA. 2011;306(20):2229-2238

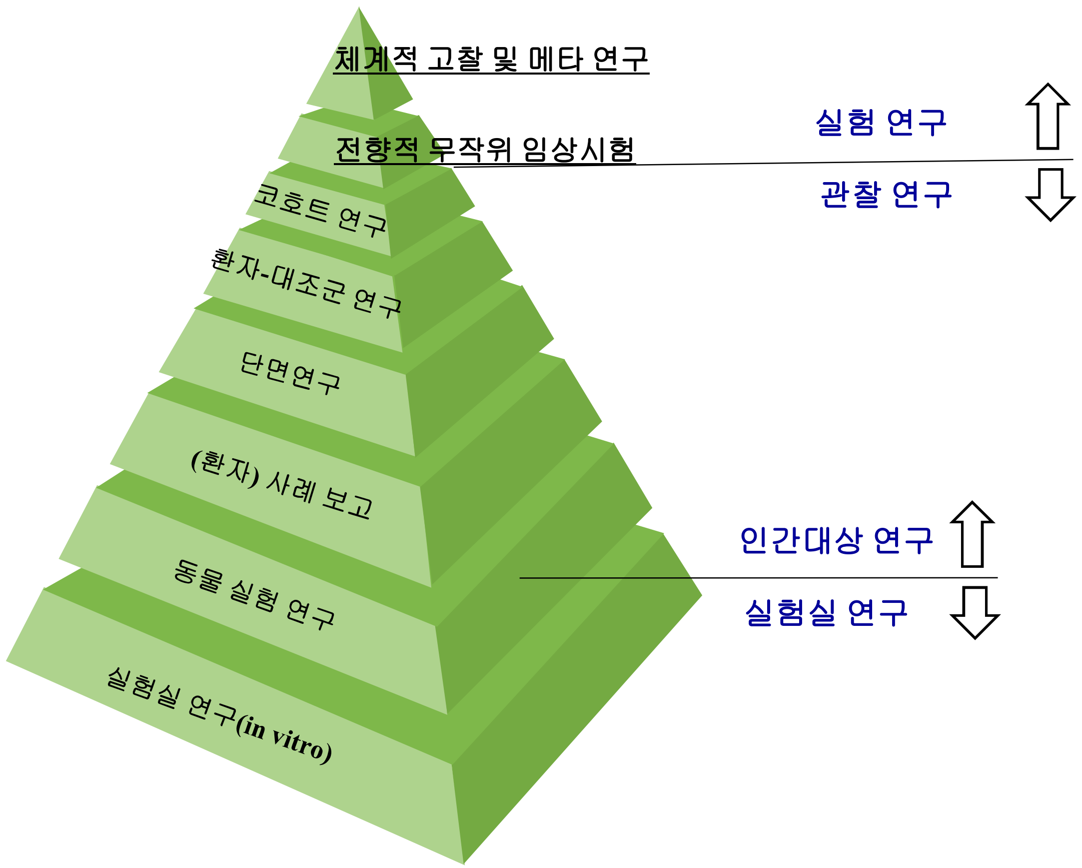


O'Donnell M. J. et al. Urinary Sodium and Potassium Excretion and Risk of Cardiovascular Events JAMA. 2011;306(20):2229-2238

Old debates

- **uncertainty of the relationship between sodium and CV risk?**
- **unclear guideline for optimal salt reduction?**

Evidence of sodium intake with CV risk



동물실험연구 사례

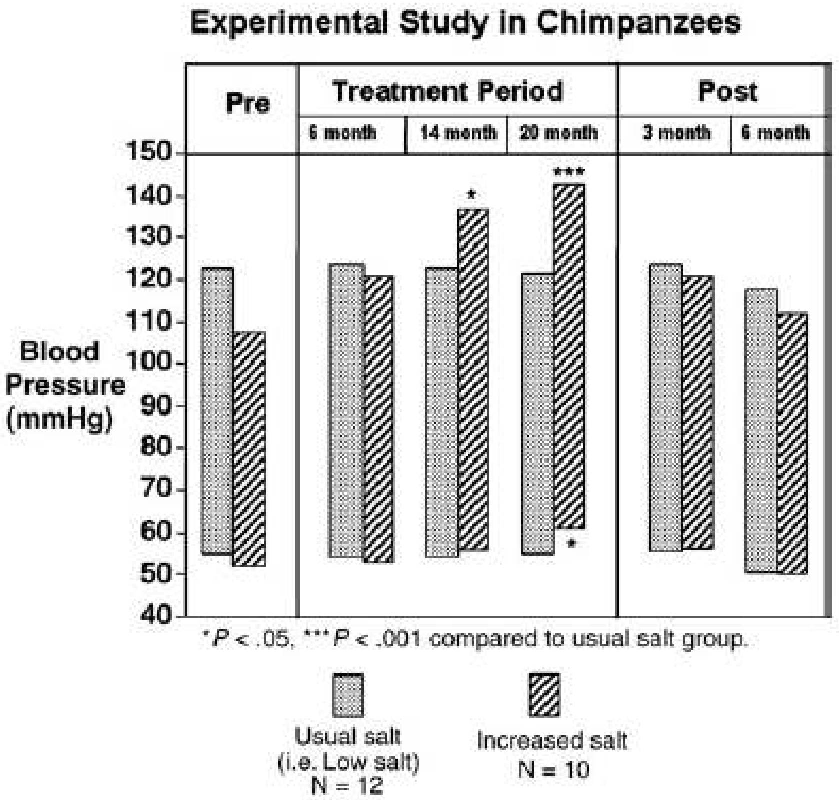


Fig 1. Blood pressure in chimpanzees that either continued on their usual low-salt diet or were given an increased salt intake. At the end of the 20-month study, the salt supplements were stopped and blood pressure declined to that of the control group. Adapted from Denton et al.[18]

He FJ, MacGregor GA. Reducing Population Salt Intake Worldwide: From Evidence to Implementation. Progress in Cardiovascular Diseases 2010;52:363–382

생태학적 연구 사례

Dahl LK. (reprint) Possible role of salt intake in the development of essential hypertension. International Journal of Epidemiology 2005;34:967–972
Dahl LK. Possible role of salt intake in the development of essential hypertension. 1960.

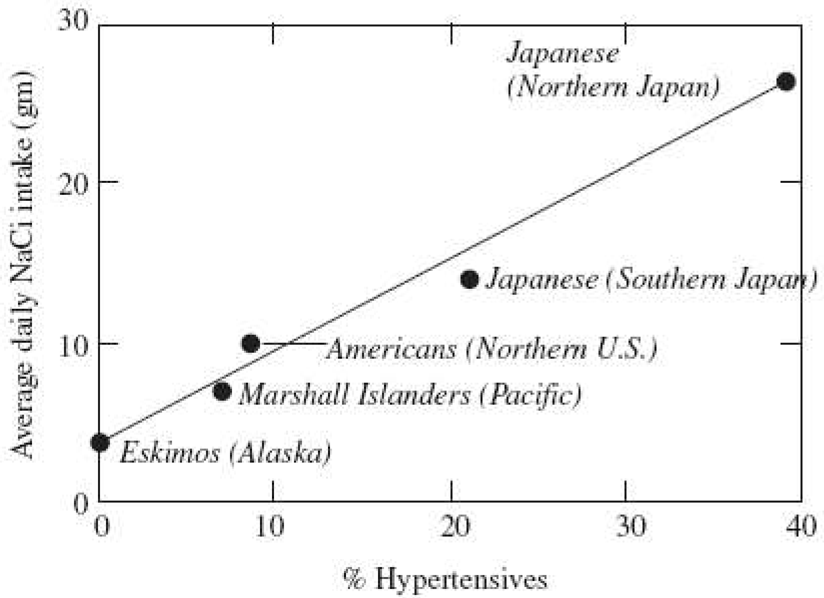


Figure 1 Correlation of average daily salt (NaCl) intakes with prevalence of hypertension in different geographic areas and among different races

생태학적 연구 사례

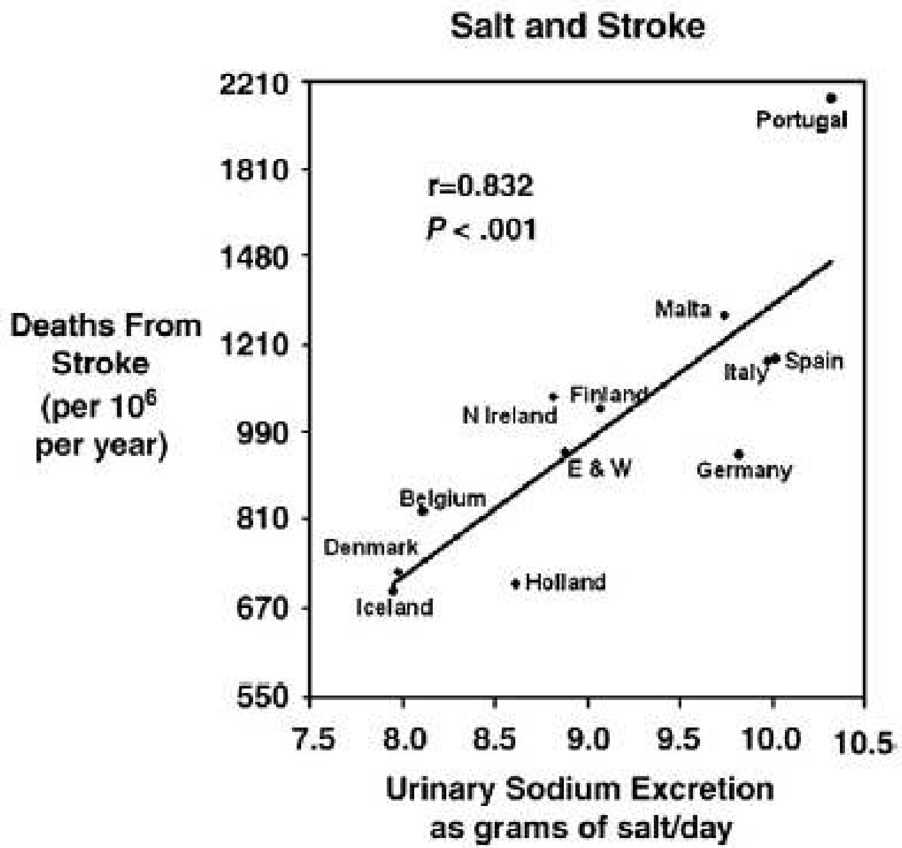
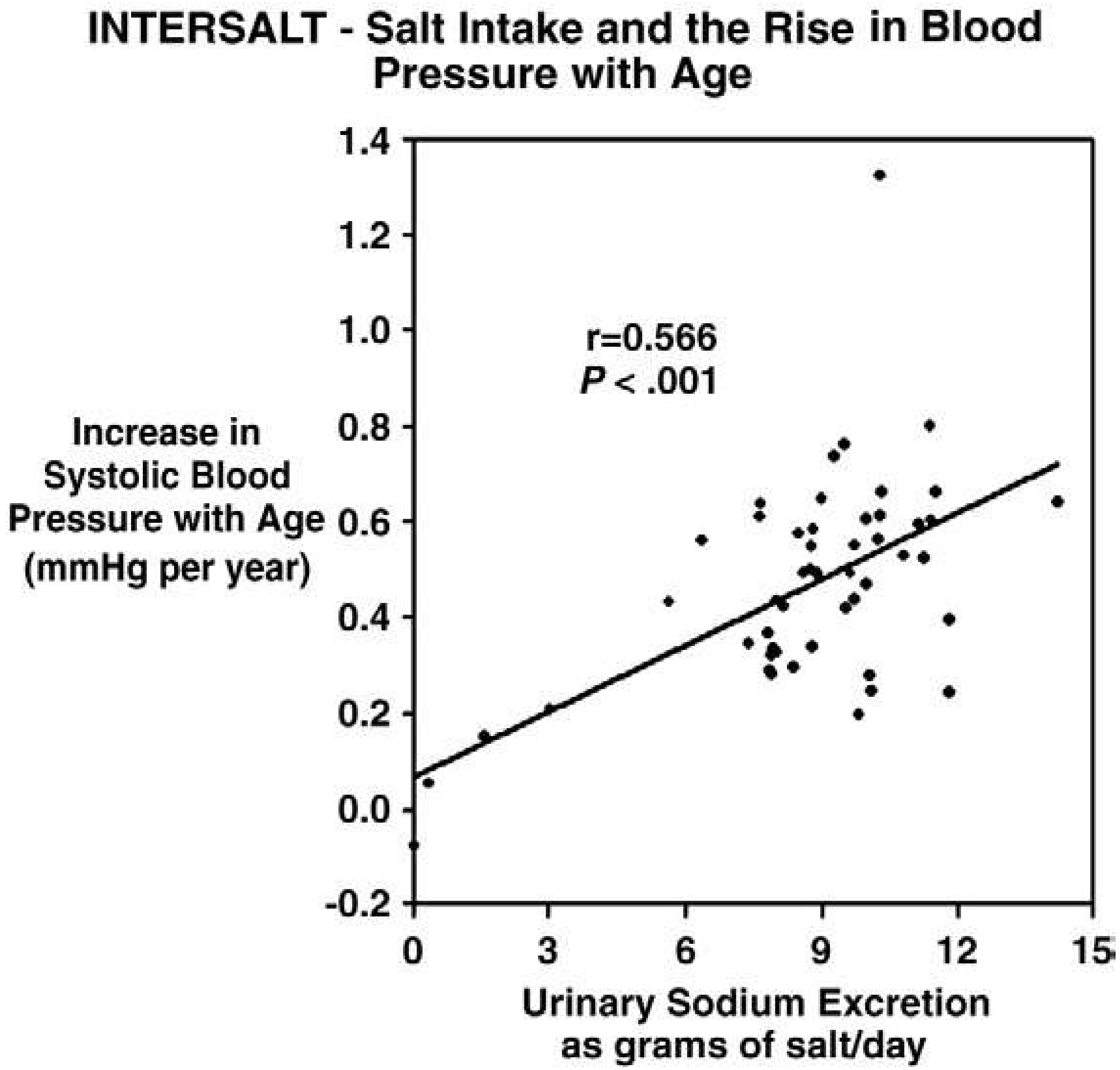


Fig 10. Relationship between salt intake and deaths from stroke in 12 European countries. Adapted from Perry and Beevers.[9]

생태학적/관찰 연구 사례



He FJ, MacGregor GA. Reducing Population Salt Intake Worldwide: From Evidence to Implementation. Progress in Cardiovascular Diseases 2010;52:363–382

관찰 연구: 전향적 코호트 연구

Positive	Weak or not sig for CVD	Inverse
• Tuomilehto J, Jousilahti P, Rastenyte D, et al. Urinary sodium excretion and cardiovascular mortality in Finland. Lancet. 2001;357(9259):848-851. • Nagata C, Takatsuka N, Shimizu N, Shimizu H. Sodium intake and risk of death from stroke in Japanese men and women. Stroke. 2004;35(7):1543-1547. • Umesawa M, Iso H, Date C, et al; JACC Study Group. Relations between dietary sodium and potassium intakes and mortality from cardiovascular disease. Am J Clin Nutr. 2008;88(1):195-202. • He J, Ogden LG, Vupputuri S, Bazzano LA, Loria C, Whelton PK. Dietary sodium intake and subsequent risk of cardiovascular disease in overweight adults. JAMA. 1999;282(21):2027-2034.	• Geleijnse JM, Witteman JC, Stijnen T, Kloos MW, Hofman A, Grobbee DE. Sodium and potassium intake and risk of cardiovascular events and all-cause mortality. Eur J Epidemiol. 2007;22(11):763-770. • Tunstall-Pedoe H, Woodward M, Tavendale R, A'Brook R, McCluskey MK. Comparison of the prediction by 27 different factors of coronary heart disease and death in men and women of the Scottish Heart Health Study. BMJ. 1997;315(7110):722-729. • Yang Q, Liu T, Kuklina EV, et al. Sodium and potassium intake and mortality among US adults. Arch Intern Med. 2011;171(13):1183-1191.	•Cohen HW, Hailpern SM, Fang J, Alderman MH. Sodium intake and mortality in the NHANES II follow-up study. Am J Med. 2006;119(3):275-14, e7-e14. •Stolarz-Skrzypek K, Kuznetsova T, Thijs L, et al;European Project on Genes in Hypertension (EPOGH)Investigators. Fatal and nonfatal outcomes, incidence of hypertension, and blood pressure changes in relation to urinary sodium excretion. JAMA. 2011;305(17):1777-1785.

중재연구 사례

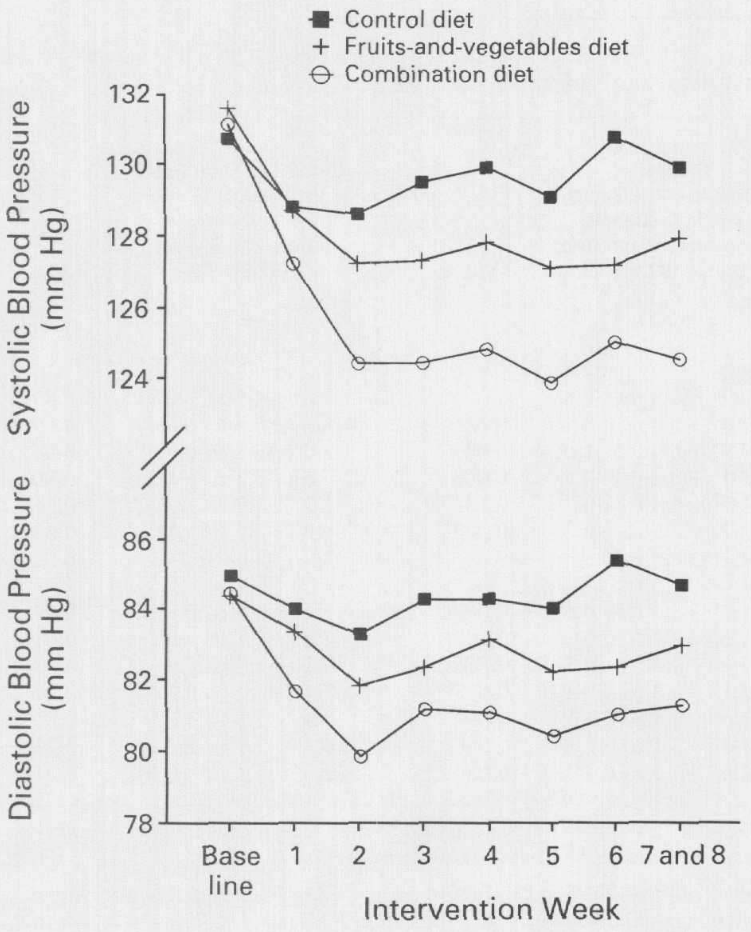
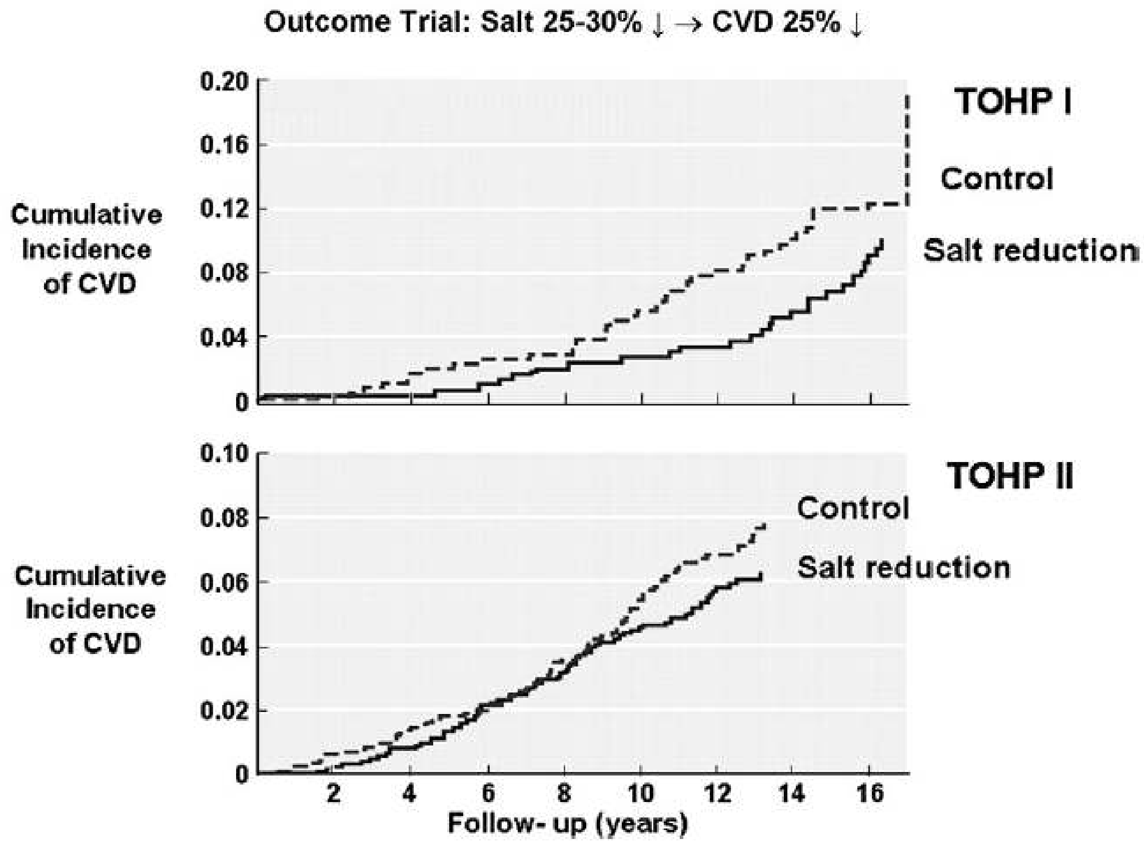


Figure 1. Mean Systolic and Diastolic Blood Pressures at Base Line and during Each Intervention Week, According to Diet, for 379 Subjects with Complete Sets of Weekly Blood-Pressure Measurements.

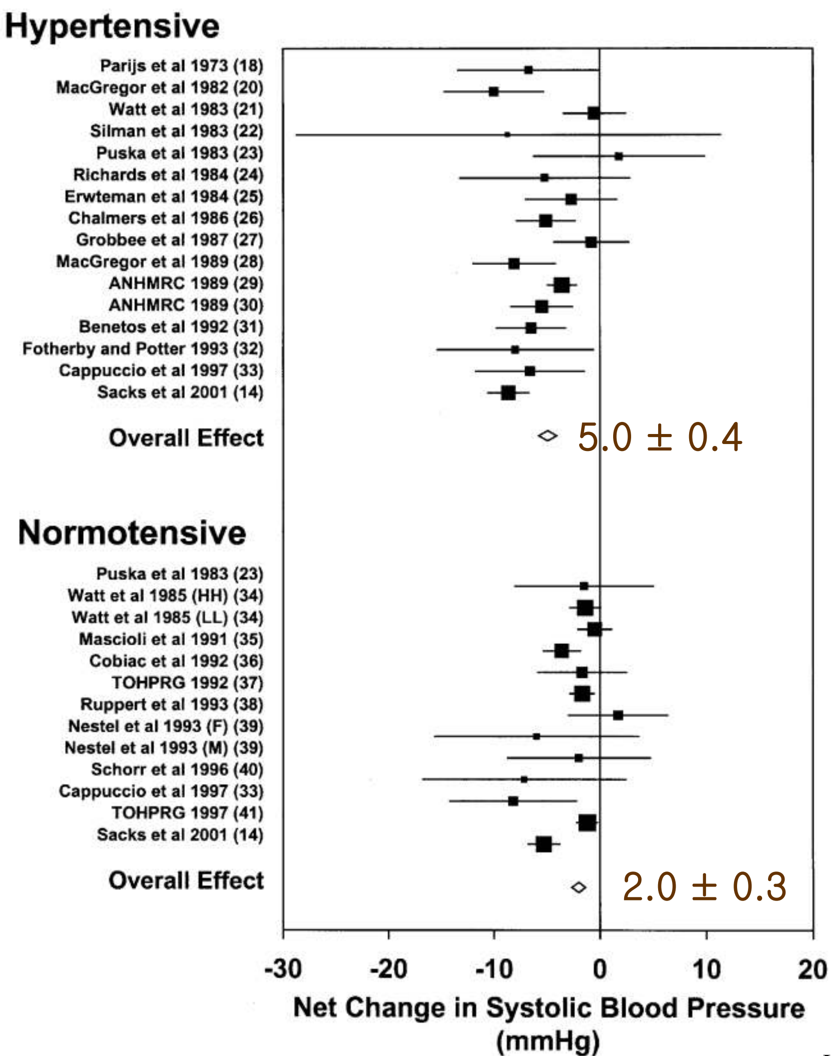
DASH dietary intervention/ clinical trial study

Lawrence J Appel, *Thomas J Moore*, *Eva Obarzanek*, *William M Vollmer*, *et al*. A clinical trial of the effects of dietary patterns on blood pressure
The New England Journal of Medicine.
1997. Vol. 336, Iss. 16; pg. *1117*, 8 pgs

임상시험


Outcome Trial: Salt 25-30% ↓ → CVD 25% ↓
Cumulative Incidence of CVD
0.20
0.16
0.12
0.08
0.04
0
TOHP I
Control
Salt reduction
Cumulative Incidence of CVD
0.10
0.08
0.06
0.04
0.02
0
TOHP II
Control
Salt reduction
2
4
6
8
10
12
14
16
Follow- up (years)

메타 연구 사례



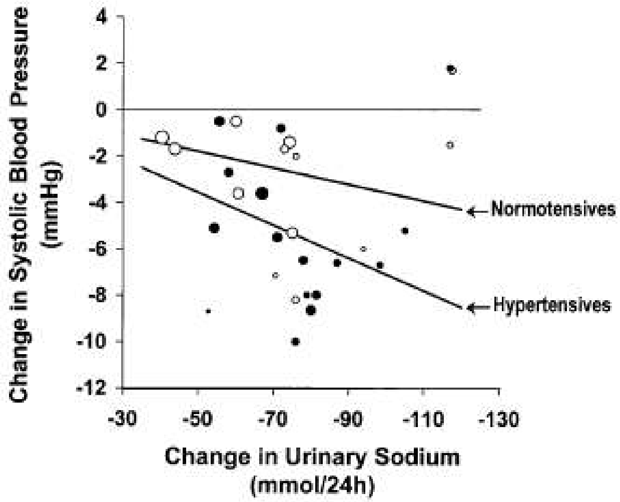


Figure 3 Relationship between the net change in urinary sodium excretion and systolic blood pressure. The open circles represent normotensives and the solid circles represent hypertensives. The slope is weighted by the inverse of the variance of the net change in systolic blood pressure. The size of the circle is in proportion to the weight of the trial.

40 mmol/d urinary sodium change
~ 2.5g/d sodium

He FJ, MacGregor GA. Effect of modest salt reduction on blood pressure: a meta-analysis of randomized trials. Implications for public health. J Hum Hypertens. 2002;16(11):761-70.

메타 연구 사례: 중재연구대상

Journal of Human Hypertension (2003) 17, 471–480

www.nature.com/jhh

ORIGINAL ARTICLE

Blood pressure response to changes in sodium and potassium intake: a metaregression analysis of randomised trials

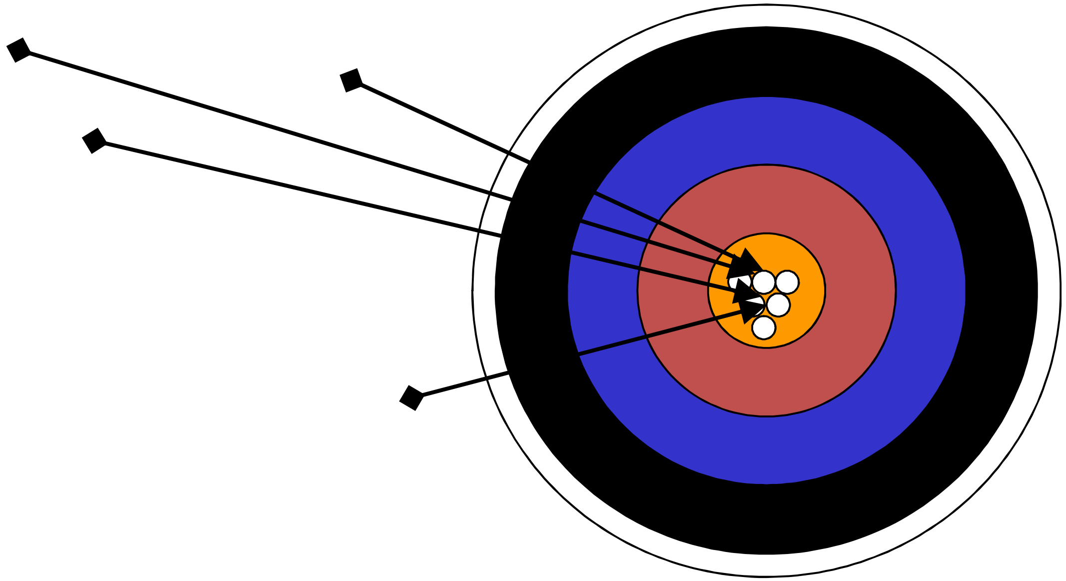
JM Geleijnse[1,2], FJ Kok[1] and DE Grobbee[2]
[1]Division of Human Nutrition & Epidemiology, Wageningen University, The Netherlands; [2]Julius Centre for Health Sciences and Primary Care, University Medical Centre Utrecht, The Netherlands

Table 2 Weighted mean blood pressure changes during sodium reduction, stratified by population characteristics and size of intervention

	Unadjusted		Adjusted[a]	
	SBP	DBP	SBP	DBP
Overall (n=47 strata)	−2.54 (−3.47, −1.60)	−1.96 (−2.56, −1.36)	−2.54 (−3.16, −1.92)	−1.96 (−2.41, −1.51)
Age				
≤45 years (n=17)	−0.68 (−1.97, 0.61)	−1.31 (−2.23, −1.64)	−1.77 (−2.88, −0.65)	−1.38 (−2.13, −0.62)
>45 years (n=30)	−3.82 (−4.90, −2.75)	−2.41 (−3.17, −1.64)	−3.07 (−4.00, −2.18)	−2.36 (−2.98, −1.74)
	P<0.001	P=0.070	P=0.10	P=0.054
Gender				
<50% men (n=13)	−3.95 (−6.42, −1.48)	−1.49 (−3.11, 0.12)	−3.33 (−5.39, −1.26)	−0.95 (−2.37, 0.47)
≥50% men (n=34)	−2.31 (−3.31, −1.30)	−2.03 (−2.69, −1.38)	−2.41 (−3.13, −1.69)	−2.12 (−2.62, −1.63)
	P=0.22	P=0.54	P=0.42	P=0.14
Hypertension[b]				
No (n=19)	−1.19 (−2.09, −0.29)	−1.06 (−1.62, −0.49)	−1.26 (−2.08, −0.43)	−1.14 (−1.76, −0.51)
Yes (n=28)	−5.38 (−6.69, −4.07)	−3.86 (−4.68, −3.04)	−5.24 (−6.56, −3.93)	−3.69 (−4.69, −2.69)
	P<0.001	P<0.001	P<0.001	P<0.001
Initial body weight[c]				
≤76 kg (n=17)	−1.77 (−2.95, −0.59)	−1.50 (−2.20, −0.80)	−2.13 (−2.96, −1.30)	−1.68 (−2.19, −1.17)
>76 kg (n=18)	−4.12 (−7.21, −1.03)	−2.03 (−3.87, −0.19)	−1.62 (−4.10, 0.85)	−0.80 (−2.32, 0.72)
	P=0.16	P=0.59	P=0.70	P=0.29
Initial 24 h-Na excretion[d]				
≤150 mmol (n=23)	−3.75 (−5.10, −2.41)	−2.24 (−3.15, −1.32)	−2.85 (−3.97, −1.73)	−2.25 (−3.09, −1.42)
>150 mmol (n=24)	−1.60 (−2.78, −0.42)	−1.74 (−2.55, −0.94)	−2.30 (−3.25, −1.35)	−1.73 (−2.44, −1.02)
	P=0.020	P=0.42	P=0.50	P=0.40
Initial 24 h-K excretion[e]				
≤60 mmol (n=14)	−3.14 (−4.72, −1.55)	−1.52 (−2.54, −0.50)	−2.94 (−4.21, −1.67)	−2.15 (−3.13, −1.18)
>60 mmol (n=33)	−2.22 (−3.38, −1.06)	−2.19 (−2.94, −1.45)	−2.32 (−3.18, −1.46)	−1.85 (−2.50, −1.21)
	P=0.35	P=0.29	P=0.47	P=0.65
Decrease in 24 h-Na excretion[f]				
≤77 mmol (n=25)	−2.00 (−2.97, −1.03)	−1.73 (−2.38, −1.08)	−2.31 (−3.05, −1.57)	−1.81 (−2.35, −1.28)
>77 mmol (n=22)	−5.03 (−7.12, −2.94)	−3.03 (−4.43, −1.62)	−3.60 (−5.44, −1.75)	−2.64 (−3.92, −1.37)
	P=0.011	P=0.099	P=0.22	P=0.25

[a]Adjusted for age, proportion of males, initial blood pressure, initial 24 h urinary sodium and potassium excretions and changes in 24 h urinary sodium excretion during the trial.
[b]SBP ≥140 mmHg and/or DBP ≥90 mmHg.
[c]According to the median of the age-, sex- and race-adjusted body weight distribution in sodium and potassium trials combined; data on initial body weight were available for 29 sodium trials (35 strata).
[d]According to the median of the distribution in sodium trials; 1 mmol Na equals 23 mg.
[e]According to the median of the distribution in potassium trials; 1 mmol K equals 39 mg.
[f]According to the median of the distribution in sodium trials.
Na: sodium; K: potassium; SBP: systolic blood pressure; DBP: diastolic blood pressure.
Values are mean blood pressure changes with 95% confidence intervals, weighted for trial sample sizes. P-values are given for the difference in blood pressure response between strata.

몇 가지 고려사항



바이어스

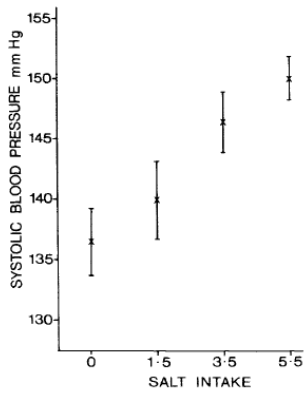
- systematic error: selection bias, information bias
- ecological fallacy vs. atomic fallacy

1970-80년대 논쟁

- 소금을 적게 먹는 사회는 다른 고혈압의 예방요인을 가지고 있을 가능성이 높다. (총 섭취 칼로리가 적고, 비만도 적고..등)
- 소금섭취 측정의 정확성 문제: 일상 섭취 측정, 섭취 소금의 정확한 표지자 등
- Dahl 연구결과의 재연 실패: Miall 등의 대규모 연구, 1984년 24시간소변을 통해 나트륨 측정한 the Scottish Heart Health Study 등

개인 단위 근거 확보

- INTERSALT study
- 개인단위 변이에 대한 근거



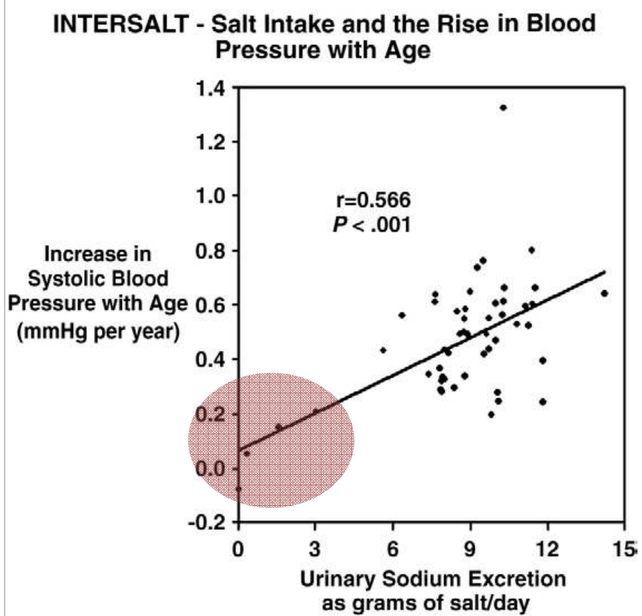
Systolic blood pressure at different levels of salt intake.

Ronald F et al. Blood pressure and salt intake: an intra population study Lancet 1981:1097

- 역학적 비교성의 문제

이상치의 처리

INTERSALT debates



- primitive society: <3.5 g/d salt intake → 즉, 산업화 사회를 대상으로 한 결과가 아님.
- 이상치 vs 선형 관련성

INTERSALT 층화분석

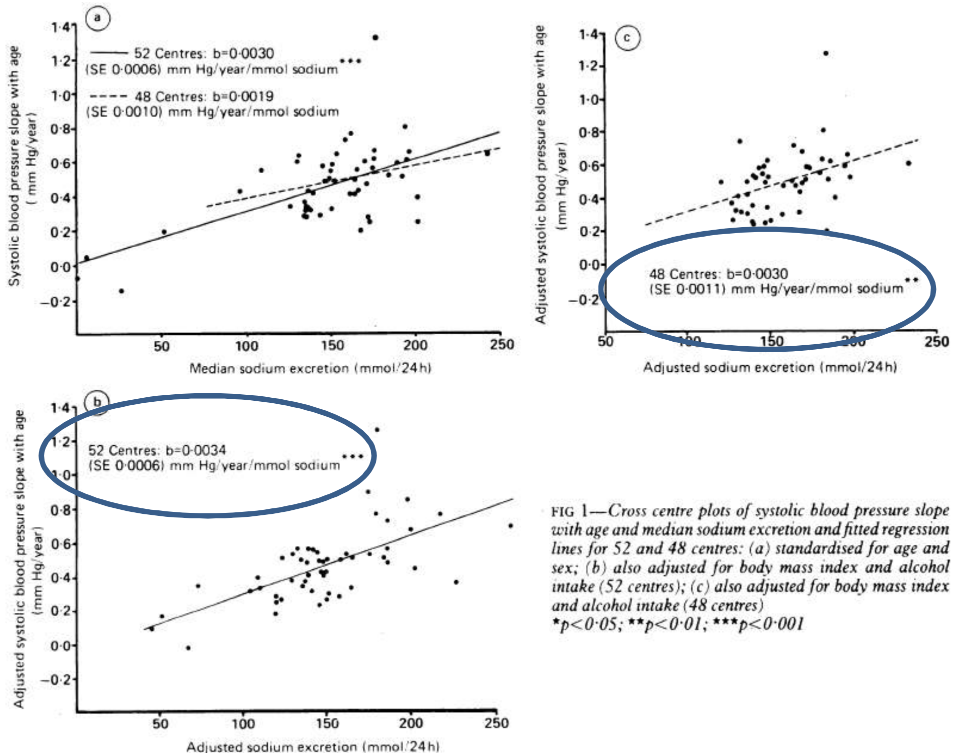


FIG 1—*Cross centre plots of systolic blood pressure slope with age and median sodium excretion and fitted regression lines for 52 and 48 centres: (a) standardised for age and sex; (b) also adjusted for body mass index and alcohol intake (52 centres); (c) also adjusted for body mass index and alcohol intake (48 centres)*
*$p<0·05$; **$p<0·01$; ***$p<0·001$

GroupIntersalt: An International Study Of Electrolyte Excretion And Blood Pressure. Results For 24Hour Urinary Sodium And Potassium ExcretionSource: BMJ: British Medical Journal, Vol. 297, No. 6644 (Jul. 30, 1988)

통계적 처리

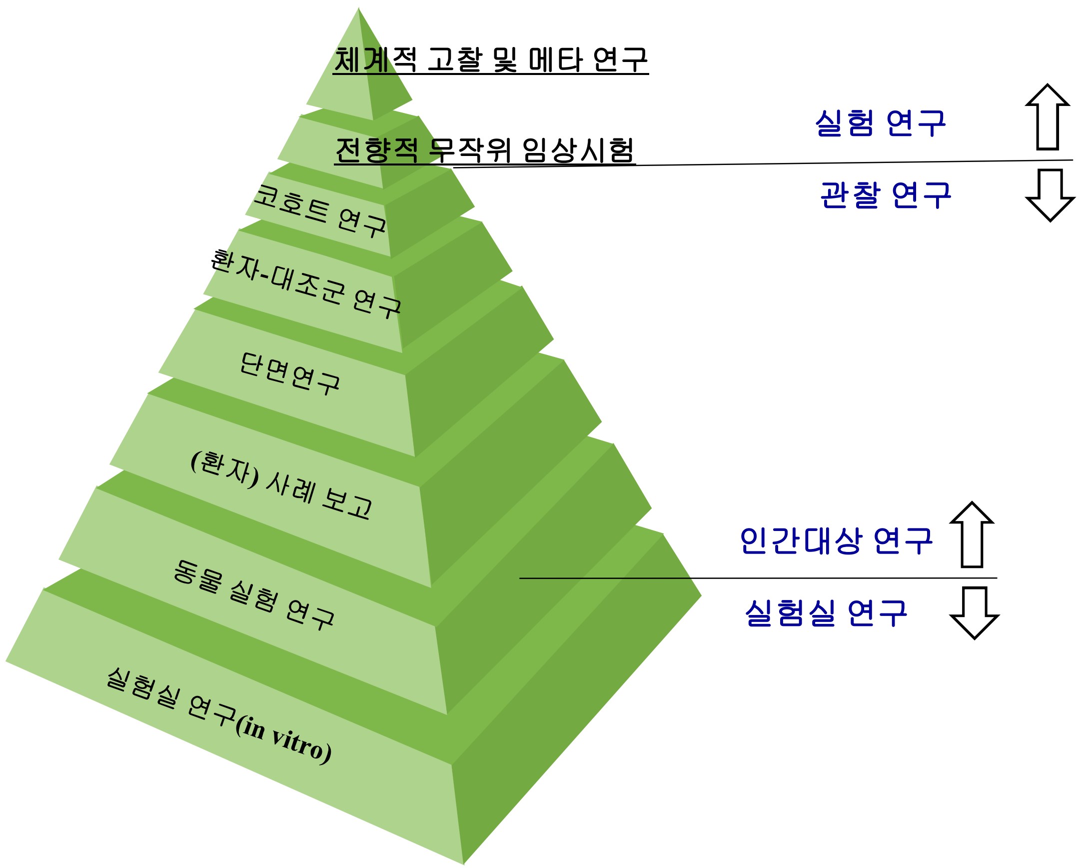
INTERSALT debates

- correction for regression dilution bias:

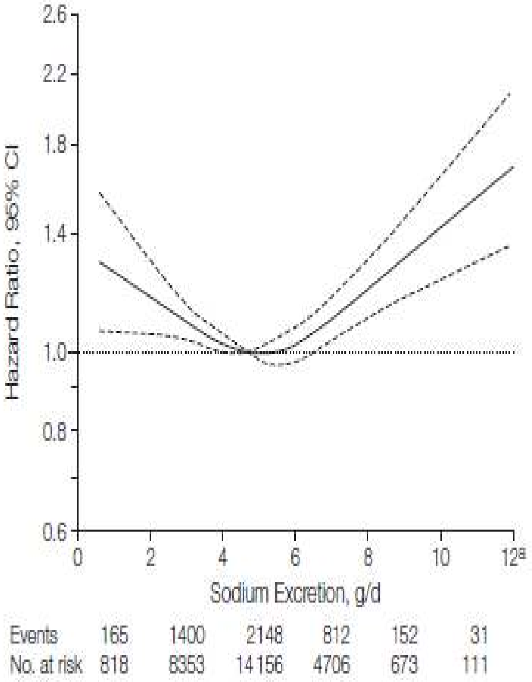
1. The gist is that if an association between two variables—such as salt and blood pressure—is real, any errors in measuring exposure to either variable will only serve to "dilute" the apparent cause and effect.
2. 보정 후 더 견고한 결과를 보고함.
3. Davey Smith 의 반론: "O level mathematical mistakes", "an inappropriately inflated estimate."

Gary Taubes. The (Political) Science of Salt. Science. 1998;281:98-907.

연구설계


체계적 고찰 및 메타 연구
전향적 무작위 임상시험
코호트 연구
환자-대조군 연구
단면연구
(환자) 사례 보고
동물 실험 연구
실험실 연구(in vitro)
실험 연구
관찰 연구
인간대상 연구
실험실 연구

앞선 연구사례에서 고려해보면,



대상자 수의 규모

- sodium excretion 2 미만은 전체 연구 대상의 매우 적은 부분

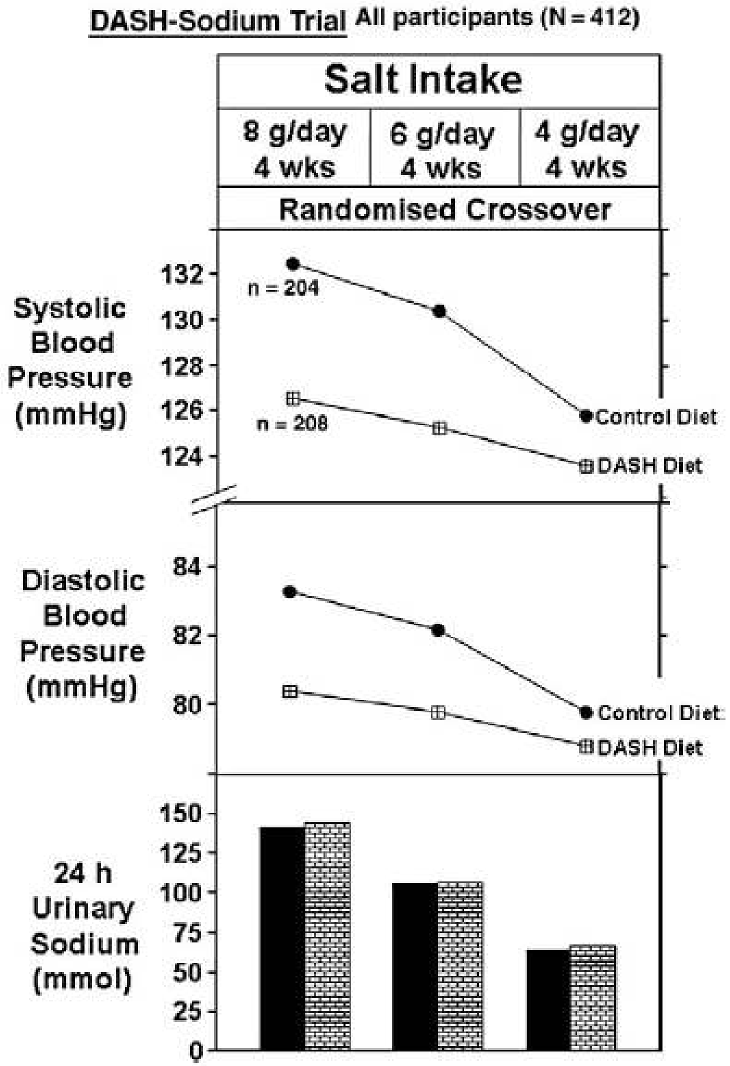
오류 가능성과 연구설계 한계

- **소금섭취 측정의 문제**
- **낮은 섭취량을 나타내는 군은 불건강하기 때문에 소금섭취를 더욱 적게 하는 것이 아닌가.**
- **관찰연구의 한계: 임상 시험 연구를 통한 근거 생산의 필요**

Randomized controlled trials have the greatest capacity to enlighten guideline recommended for sodium intake…….To be convincing these finding would first have to be replicated in high-quality studies.

Whelton P. K. JAMA. 2011;306:2262-2264

식이요인의 복잡성



- 결과의 해석

→ 소금섭취 제한의 효과성 관찰

→ DASH 식이의 효과성 관찰

→ 소금섭취와 DASH 식이의 더한 효과가 관찰되지 않는다?/ DASH 식이와 소금섭취 제한의 상호작용의 존재?

- 다양한 식이요인의 관여

: 포타슘, 알코올, 칼슘, 마그네슘, 생선 기름 등.

Sodium threshold

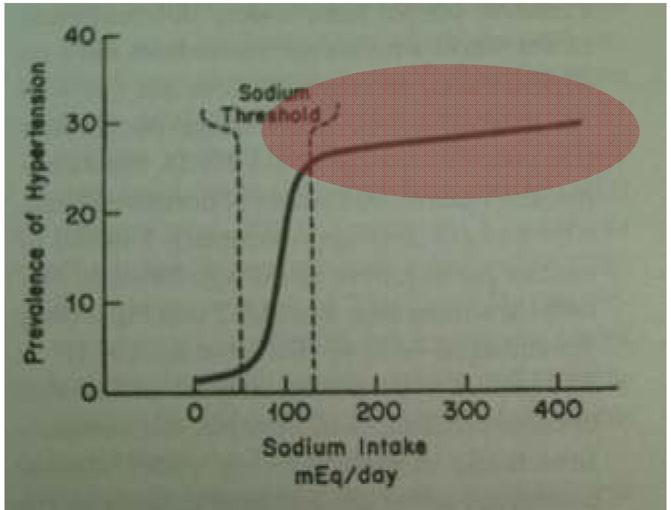


FIG. 3-7. Probable association between usual dietary sodium intake and the prevalence of hypertension in large populations. (Reprinted from Kaplan NM. Dietary salt intake and blood pressure. *JAMA* 1984;251:1429–1430, Copyright 1984, American Medical Association, with permission.)

100 mEq sodium
= 6 g salt

일정 소금 이상을 섭취하면 고혈압의 유병은 급격하게 늘어나지 않는다?

• 소금 섭취량이 높은 사회에서 고혈압의 변이를 파악하기 어려운 결과 파생, 즉 역학적 비교성의 문제!

→모두 담배를 피는 사회에서 폐암의 위험요인으로 흡연을 찾을 수 있을까?

• 나트륨에 민감한 사람은 따로 존재?

→Renal pressure natriuresis impairment in all forms of human HT

→Steady state relationships between arterial pressure and urinary sodium intake for HT: salt sensitive, salt insensitive HT

역학적 비교성

높은 소금 섭취량의 문제

- In the early 1980s, London School of Tropical Medicine and Hygiene epidemiologist Geoffrey Rose suggested another reason why the intrapopulation studies might fail to detect benefits of salt reduction that could still have a significant public health impact. Rose speculated that if the entire developed world consumed too much salt, as ecologic studies suggested, then epidemiology would never be able to link salt to hypertension, regardless of how causal the relationship. Imagine, he wrote, if everyone smoked a pack of cigarettes daily; then any intrapopulation study "would lead us to conclude that lung cancer was a genetic disease … since if everyone is exposed to the necessary agent, then the distribution of cases is wholly determined by individual susceptibility."

- 인류 발전과 유전적 적응의 문제

: 이미 모든 사회/국가는 인류 초기에 비해 과다한 소금을 섭취하고 있다
→ 유전적 적응된 인류 vs. 과다한 소금섭취에 의해 고혈압 등 문제 발생

Gary Taubes. The (Political) Science of Salt. Science. 1998;281:98-907.

역학적 비교성?: 국내 단면연구 사례

Table 3. Odds ratios (ORs) and 95% confidence intervals (CIs) according to the intake of selected nutrients of the normotensive and hypertensive subjects (Chungcheong province, KNHANES III)

	Normotensive (n = 392)	Hypertensive (n = 152)	ORs (95% CI) Crude ORs	Multivariate ORs[1]
Sodium (mg)				
T1 (< 3,977.6)	129	56	1	1
T2 (3,977.6- < 6,139.7)	130	36	0.61 (0.38-0.98)	0.59 (0.26-1.35)
T3 (≥ 6,139.7)	130	53	0.77 (0.42-1.41)	0.54 (0.21-1.38)
P for trend			0.489	0.216
Potassium (mg)				
T1 (< 2,197.1)	129	57	1	1
T2 (2,197.1- < 3,153.6)	130	41	0.71 (0.40-1.27)	0.43 (0.20-0.89)
T3 (≥ 3,153.6)	130	47	0.72 (0.34-1.50)	0.35 (0.11-1.07)
P for trend			0.438	0.088
Calcium (mg)				
T1 (< 380.5)	129	63	1	1
T2 (380.5- < 572.6)	130	34	0.54 (0.33-0.91)	0.43 (0.21-0.88)
T3 (≥ 572.6)	130	48	0.82 (0.46-1.47)	0.43 (0.20-0.90)
P for trend			0.620	0.040
Sodium/Potassium ratio				
T1 (< 1.5740)	130	47	1	1
T2 (1.5740- < 2.2040)	130	36	0.69 (0.34-1.37)	0.70 (0.35-1.38)
T3 (≥ 2.2040)	129	62	1.25 (0.73-2.15)	1.22 (0.76-1.98)
P for trend			0.254	0.212
Sodium/Calcium ratio				
T1 (< 8.6110)	130	41	1	1
T2 (8.6110- < 12.6246)	130	40	0.89 (0.66-1.21)	0.78 (0.46-1.33)
T3 (≥ 12.6246)	129	64	1.58 (1.01-2.47)	2.10 (1.25-3.52)
P for trend			0.042	0.002
Following the instruction for eating a healthy diet (ex. reducing salt consumption)				
take action	131	40	1	1
try to practice	164	59	1.29 (0.82-2.03)	1.24 (0.66-2.35)
do not practice	97	51	1.98 (1.08-3.62)	1.64 (0.88-3.04)

[1] Adjusted for age (19-29, 30-49, 50-64, ≥ 65), sex, education (middle school or lower, high school, college or higher), BMI, alcohol drinking (drinker, non-drinker) and energy intake.

Jung-Sug Lee, Juyeon Park and Jeongseon Kim. Dietary factors related to hypertension risk in Korean adults-data from the Korean national health and nutrition examination survey III.Nutrition Research and Practice (Nutr Res Pract) 2011;5(1):60-65

혼란변수/다른 기전

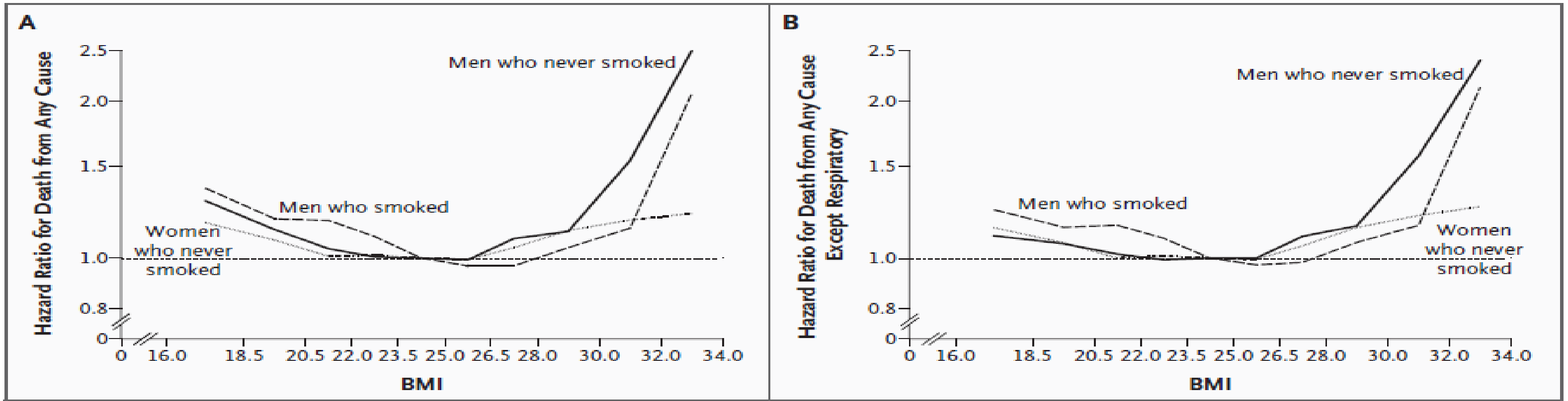
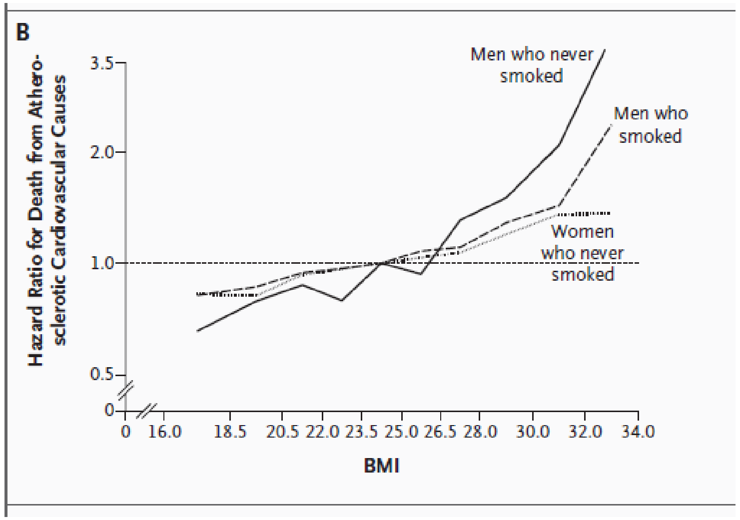
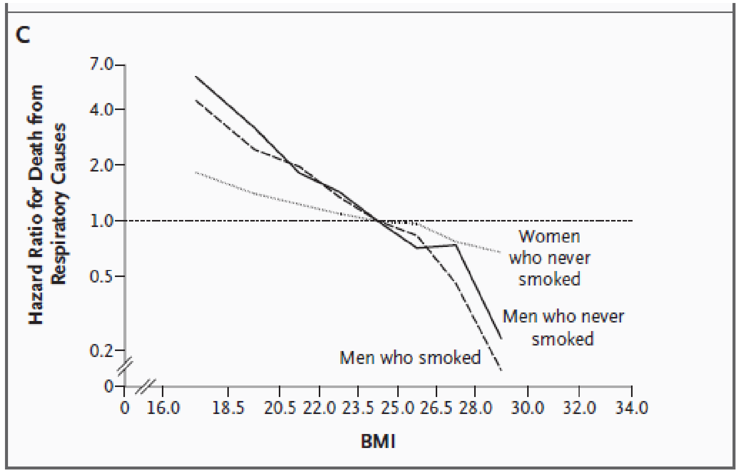


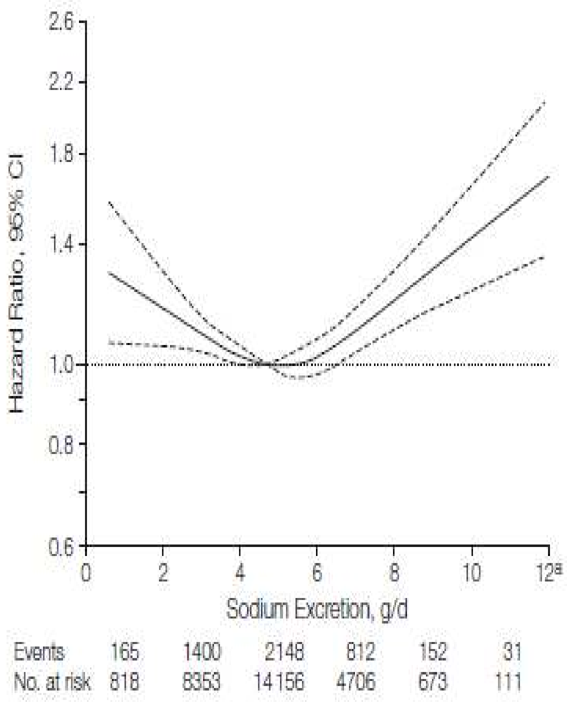
Figure 1. Hazard Ratios for Death from Any Cause and from Any Cause Except Respiratory, According to BMI and Smoking History.
Data are from the KCPS, 1993–2004.[12,13] The reference category was a BMI of 23.0 to 24.9. Results for men who reported having smoked cigarettes were further adjusted for whether the subject was a former smoker or a current smoker and the number of cigarettes smoked per day (1 to 9, 10 to 19, and 20 or more). All hazard ratios were adjusted for age.





Jee SH et al. Body-Mass Index and Mortality in Korean Men and Women. N Engl J Med 2006;355:779-87.

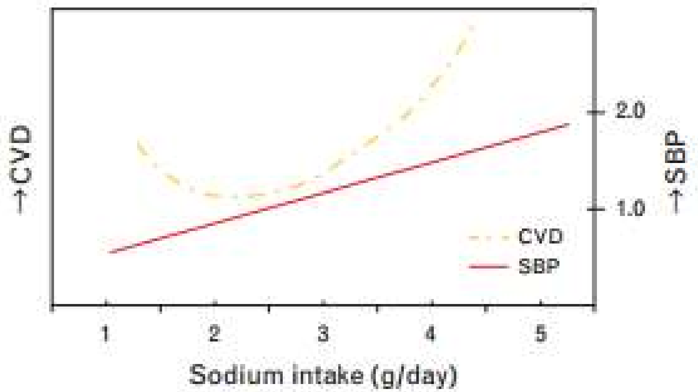
앞선 연구사례에서 고려해보면,



- 소금섭취와 결과변수에 모두 영향을 줄 수 있는 다른 요인은 없는가?
    - 질병 심각도, 약물(이뇨제..), 다른 식이영향 등
- 양의 연관과 음의 연관은 같은 기전에 의한 것인가?
    - metabolic disturbance
- 일반인구가 아닌 고연령, 복합만성질환력을 지닌 연구대상의 특징
- 고혈압과 소금섭취의 관련성 외 CVD 관련성과의 다른 기전

Sodium J curve

Fig. 2



The relation of dietary sodium intake to systolic blood pressure (SBP) and cardiovascular events (CVD). In normotensive persons a decrease in sodium intake of 160 mmol produces a 1.2 mmHg fall in systolic blood pressure.

• 소금섭취가 높은 지역사회에서, 높은 소금섭취는 CVD와 양의 관계를 보이나, 중등도 섭취 국가에서는 낮은 소금섭취의 부작용, Plasma Renin Angiotensin, 교감신경활성화, insuline resistance 등의 효과가 혈압 감소의 효과를 상쇄할 것으로 봄.

Table 3 Health outcomes associated with lower versus higher sodium intake: moderate-intake societies

Study	Year	D/U	Na^+ (mg/day)	Outcome
HHS [12]	1985	D	2000	L = H
WSH [13]	1995	U	2600	L > H
SHS [20]	1997	D	???	Mixed
HPS [18]	1997	D	3000	L = H
NHANES I [16]	1998	D	2400	L > H
MRFIT [17]	2000	D	2921	L = H
NHANES I [19][a]	2000	D	2000	L < H
NHANES II [15]	2006	D	2718	L > H

D/U, sodium estimated by diet (D) or 24-h urine collection (U); H, higher sodium intake; HHS, Honolulu Heart Study; HPS, Health Professionals Follow-up Study; L, lower sodium intake; MRFIT, Multiple Risk Factor Intervention Trial; NHANES, National Health and Nutrition Examination Survey; SHS, Scottish Heart Health Study; WSH, Worksite Hypertension Study. [a] 28% obese.

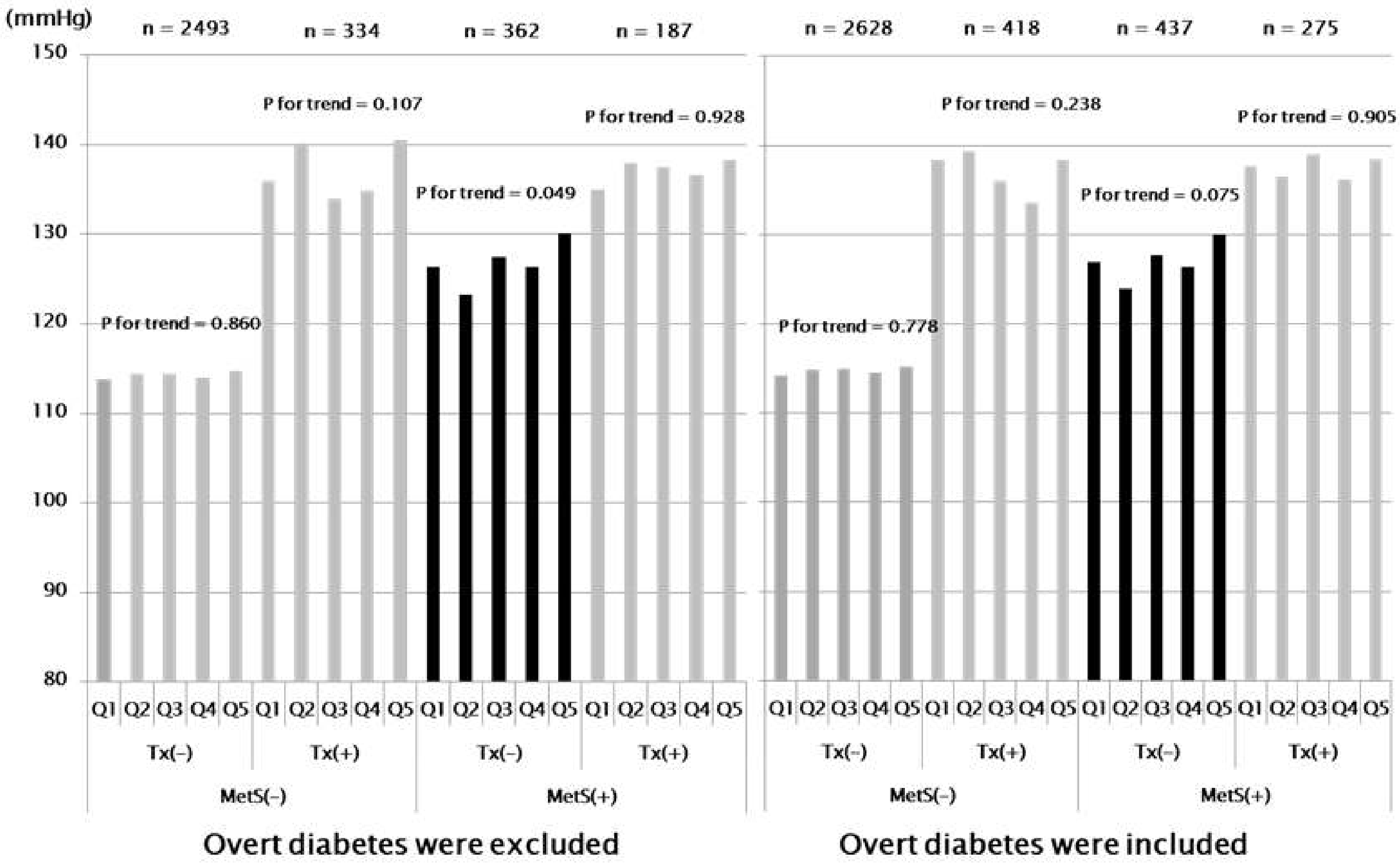
Table 4 Health outcomes associated with lower versus higher sodium intake: high-intake societies

Study	Year	D/U	Na^+ (mg/day)	Outcome
FHS [21]	2001	U	±4600	L < H
Takayama [14]	2005	U	±5400	L < H

D/U, sodium estimated by diet (D) or 24-h urine collection (U); FHS, Finish Heart Study; H, higher sodium intake; L, lower sodium intake.

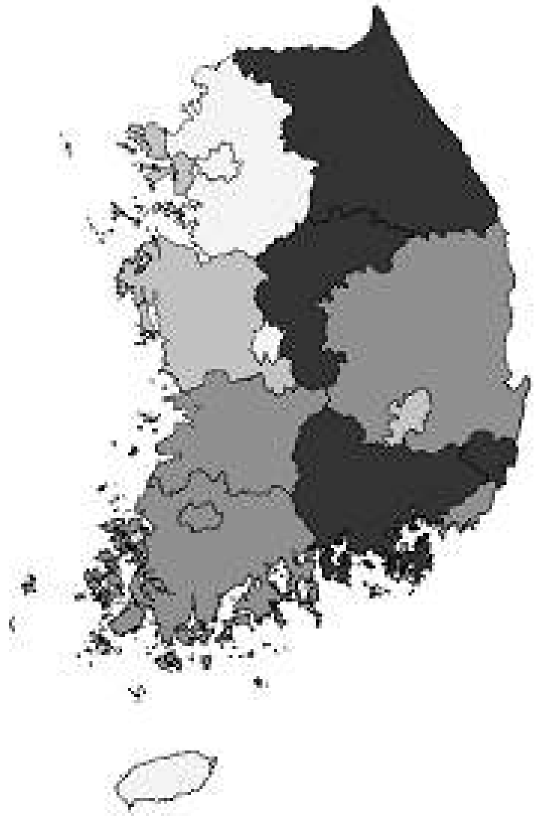
Alderman M. H. J Hypertens. 2007;25:903-907

MS as salt sensitivity: 국내 연구 사례



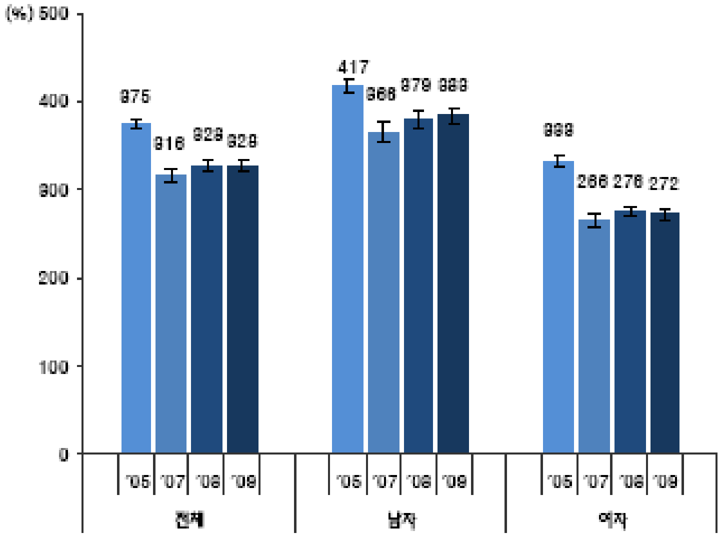
Kim BK, Lim YH, Kim SG, Kim YM, Shin J. Relationship between sodium intake and blood pressure according to metabolic syndrome status in the Korean National Health and Nutrition Examination Survey.Blood Press Monit. 2012 Jun;17(3):120-7.

국내 고혈압, 소금섭취 현황



국내 나트륨 섭취량

그림 14. 나트륨 충분섭취량에 대한 섭취비율 추이



※충분섭취량 : 한국인 영양섭취기준(한국영양학회, 2005)

1) 영양섭취기준
- 제1기(1998) : 한국인 영양권장량 제6차 개정(한국영양학회, 1995)
- 제2기(2001) : 한국인 영양권장량 제7차 개정(한국영양학회, 2000)
- 제3, 4기(2005, 2007-2009) : 한국인 영양섭취기준(한국영양학회, 2005)
- 에너지, 필요추정량(또는 권장량)의 125%; 지방, 지방에너지적정비율의 상한선; 그 외 영양소, 상한섭취량(또는 권장량의 125%)

2) 2005년 추계인구로 연령표준화
3) '-' : 한국인 영양권장량 제6차 및 제7차 개정에는 지방에 대한 에너지적정비율, 나트륨 영양섭취기준 미비
4) 분율 0.1%미만으로 표준오차 미제시
5) 9세미만에 대해서는 나트륨 목표량이 없으므로 9세이상에 대해 산출

보건복지부, 질병관리본부. 2009년 건강통계: 4기 3차 국건영조사 결과

전체 인구, 나트륨 섭취량 시기별 변화: 1998-2009

구분		국민건강영양조사 '98 (N=10,400) 평균	(표준오차)	'01 (N=9,968) 평균	(표준오차)	'05 (N=8,930) 평균	(표준오차)	'07 (N=4,091) 평균	(표준오차)	'08 (N=8,631) 평균	(표준오차)	'09 (N=9,391) 평균	(표준오차)	'07-'09 (N=22,113) 평균	(표준오차)
에너지(kcal)		1,933.5	(11.3)	1,896.7	(11.4)	1,979.1	(11.5)	1,829.6	(15.9)	1,867.5	(12.5)	1,883.4	(11.5)	1,866.3	(7.5)
단백질(g)		73.2	(0.7)	70.9	(0.5)	75.0	(0.5)	66.0	(0.7)	66.7	(0.6)	67.6	(0.5)	66.9	(0.3)
지방(g)		40.1	(0.4)	41.7	(0.5)	45.2	(0.4)	37.9	(0.6)	39.3	(0.5)	40.5	(0.4)	39.5	(0.3)
탄수화물(g)		315.5	(1.9)	296.9	(1.7)	301.0	(1.7)	292.7	(2.4)	297.7	(1.7)	298.8	(1.7)	297.2	(1.1)
조섬유(g)		6.6	(0.1)	6.9	(0.1)	7.2	(0.1)	6.3	(0.1)	6.7	(0.1)	6.7	(0.1)	6.6	(0.0)
칼슘(mg)		500.5	(5.1)	495.5	(4.4)	552.4	(5.0)	468.9	(6.3)	488.5	(4.9)	491.9	(4.5)	486.0	(3.0)
인(mg)		1,060.6	(7.0)	1,142.8	(7.2)	1,229.4	(7.9)	1,080.1	(10.0)	1,116.7	(8.0)	1,121.4	(7.3)	1,112.5	(4.8)
나트륨(mg)		4,581.6	(40.6)	4,966.9	(39.8)	5,260.2	(42.9)	4,452.9	(54.3)	4,607.6	(42.5)	4,617.5	(39.3)	4,561.1	(25.5)
칼륨(mg)		2,522.4	(19.2)	2,831.7	(19.6)	2,774.4	(18.3)	2,704.0	(28.3)	2,890.2	(22.8)	2,832.7	(20.5)	2,806.1	(13.5)
철(mg)		12.5	(0.1)	12.3	(0.1)	13.8	(0.1)	13.1	(0.2)	13.3	(0.2)	13.4	(0.1)	13.3	(0.1)
비타민A(μgRE)		609.5	(8.4)	628.8	(9.1)	781.7	(9.5)	734.4	(17.7)	770.8	(14.6)	766.4	(12.1)	761.7	(8.4)
티아민(mg)		1.33	(0.01)	1.28	(0.01)	1.31	(0.01)	1.21	(0.02)	1.24	(0.01)	1.26	(0.01)	1.25	(0.01)
리보플라빈(mg)		1.08	(0.01)	1.15	(0.01)	1.21	(0.01)	1.07	(0.01)	1.16	(0.01)	1.20	(0.01)	1.16	(0.01)
나이아신(mg)		15.5	(0.1)	16.8	(0.1)	17.0	(0.1)	14.7	(0.2)	15.1	(0.1)	15.4	(0.1)	15.2	(0.1)
비타민C(mg)		123.7	(1.5)	134.6	(1.6)	99.1	(1.2)	93.0	(1.9)	99.7	(1.4)	100.2	(1.3)	98.6	(0.9)
급원별 에너지 섭취분율(%)2)	단백질	15.0	(0.1)	15.1	(0.1)	15.5	(0.1)	14.7	(0.1)	14.6	(0.1)	14.6	(0.1)	14.6	(0.0)
	지방	17.9	(0.1)	19.1	(0.1)	20.3	(0.1)	18.4	(0.2)	18.6	(0.1)	19.0	(0.1)	18.7	(0.1)
	탄수화물	67.2	(0.1)	65.8	(0.1)	64.2	(0.1)	66.9	(0.2)	66.8	(0.1)	66.4	(0.1)	66.7	(0.1)

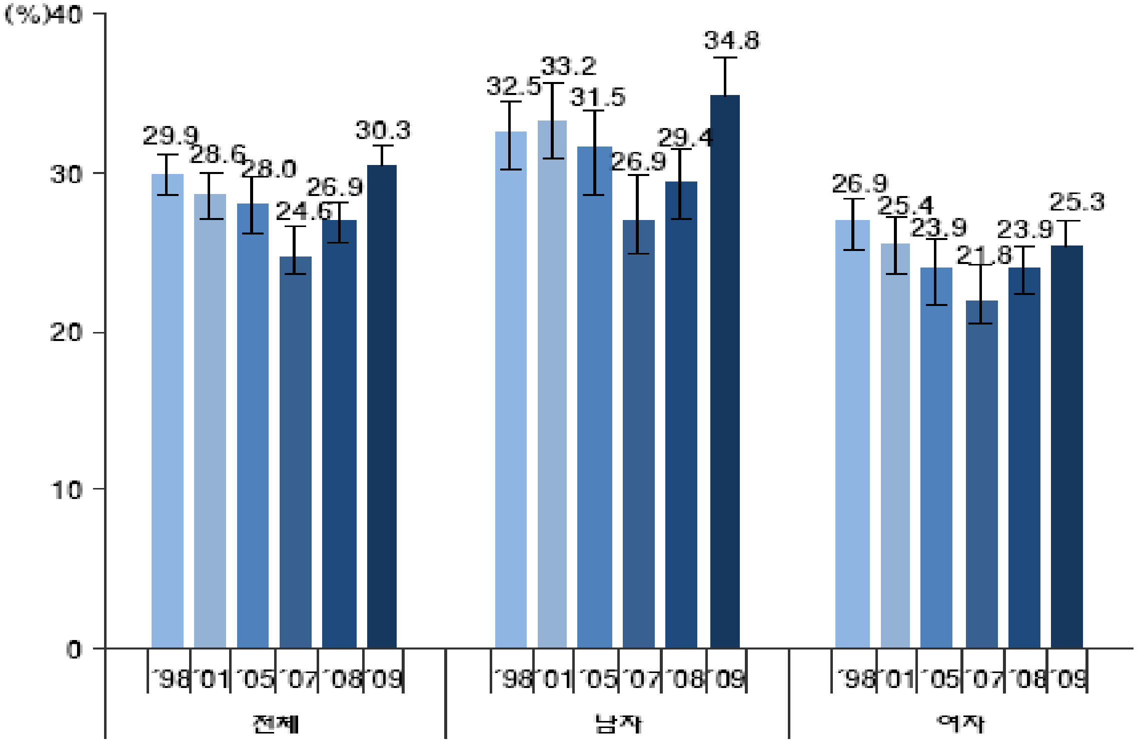
1) '69~'95년 원시자료 확보 불가로 이전 보고서에 수록된 값 제시, '98~'07년 자료에 한해 2005년 추계인구로 연령표준화

2) 단백질급원 에너지섭취분율 : {(단백질 섭취량)×4}의 {(단백질 섭취량)×4+(지방 섭취량)×9+(탄수화물 섭취량)×4}에 대한 분율
지방 및 탄수화물급원 에너지섭취분율 : 단백질급원 에너지섭취분율과 같은 정의에 의해 산출

보건복지부, 질병관리본부. 2009년 건강통계: 4기 3차 국건영조사 결과

고혈압 유병률과 추이

그림 42. 고혈압 유병률 추이



※고혈압 유병률 : 수축기혈압이 140mmHg 이상이거나 이완기혈압이 90mmHg 이상 또는 혈압강하제를 복용한 분율, 만30세이상

※2005년 추계인구로 연령표준화

※2009년 결과는 잠정치로, 자료 추가 검토 중

보건복지부, 질병관리본부. 2009 국민건강통계

고혈압 유병률과 추이

Table 1. Prevalence rates for normotensive, borderline and hypertensive blood pressures

(%)

	Male			Female		
	Normotensive	Borderline	Hypertensive	Normotensive	Borderline	Hypertensive
Systolic	69.8	20.6	9.6(6.6)	80.9	12.3	6.8(4.3)
Diastolic	65.4	15.0	19.6(17.8)	76.3	10.9	12.8(10.0)
Combined	56.4	30.6	14.0(10.8)	69.8	20.4	9.8(7.5)

(   ) age adjusted

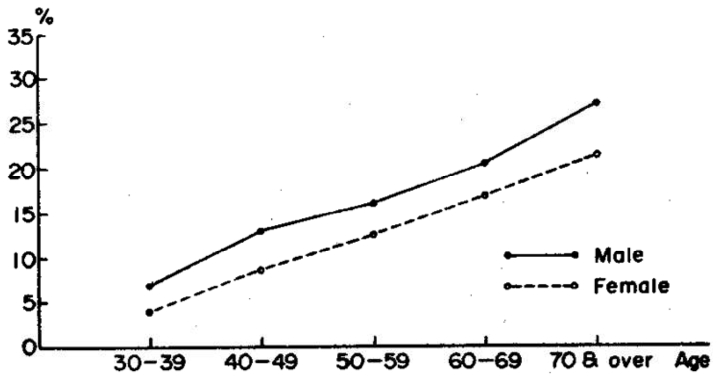


Fig. 9. Prevalence rates of hypertension by age and sex.

Kim IS et al. Yonsei Medical Journal. 1982;23:15-25

소결

국내 연구근거의 확립 필요

- 소금 섭취 측정의 타당도 제고
- 단면연구 외 연구설계 다변화
  - 통시적 모니터링의 필요
  - 시험연구/국제적 비교 등 연구설계 다각화 필요
- 한국인의 소금제안 효과성 검증 및 관련 요인 탐색을 통한 정책적 권고 마련필요

Table 1
Diet-related lifestyle recommendations to lower blood pressure

Lifestyle Modification	Recommendation
Weight loss	For overweight or obese persons, lose weight, ideally attaining a body mass index <25 kg m^2 For non-overweight persons, maintain desirable body mass index <25 kg m^2
Reduced sodium intake	Lower sodium intake as much as possible, with a goal of no more than 2300 mg d in the general population and no more than 1500 mg d in blacks, middle- and older-aged persons, and individuals with hypertension, diabetes, or chronic kidney disease
DASH-style dietary pattern	Consume a diet rich in fruits and vegetables (8–10 servings d), rich in low-fat dairy products (2–3 servings d), and reduced in saturated fat and cholesterol
Increased potassium intake	Increase potassium intake to 4.7 gm d, which is also the level provided in the DASH diet
Moderation of alcohol intake	For those who drink alcohol, consume _2 alcoholic drinks per day (men) and _1 alcohol drinks/d (women)[a]

DASH, Dietary Approaches to Stop Hypertension.
[a] One alcoholic drink is defined as 12 oz of regular beer, 5 oz of wine (12% alcohol), or 1.5 oz of 80 proof distilled spirits.[16]

Lawrence J. Appel, MD, MPH, on behalf of the American Society of Hypertension Writing Group. ASH position paper: Dietary approaches to lower blood pressureJournal of the American Society of Hypertension 4(2) (2010) 79–89

인구집단 접근 중재의 필요성

In the early 1980s, London School of Tropical Medicine and Hygiene epidemiologist Geoffrey Rose suggested another reason why the intrapopulation studies might fail to detect benefits of salt reduction that could still have a significant public health impact. Rose speculated that if the entire developed world consumed too much salt, as ecologic studies suggested, then epidemiology would never be able to link salt to hypertension, regardless of how causal the relationship. Imagine, he wrote, if everyone smoked a pack of cigarettes daily; then any intrapopulation study "would lead us to conclude that lung cancer was a genetic disease … since if everyone is exposed to the necessary agent, then the distribution of cases is wholly determined by individual susceptibility." Thus, as with salt and high blood pressure, the clues would have to be "sought from differences between populations or from changes within populations over time." By the same logic, cutting salt consumption a small amount might have little effect on a single individual—just as going from 20 cigarettes to 19 would—but a major impact on mortality across an entire population.

높은 비용-효과성

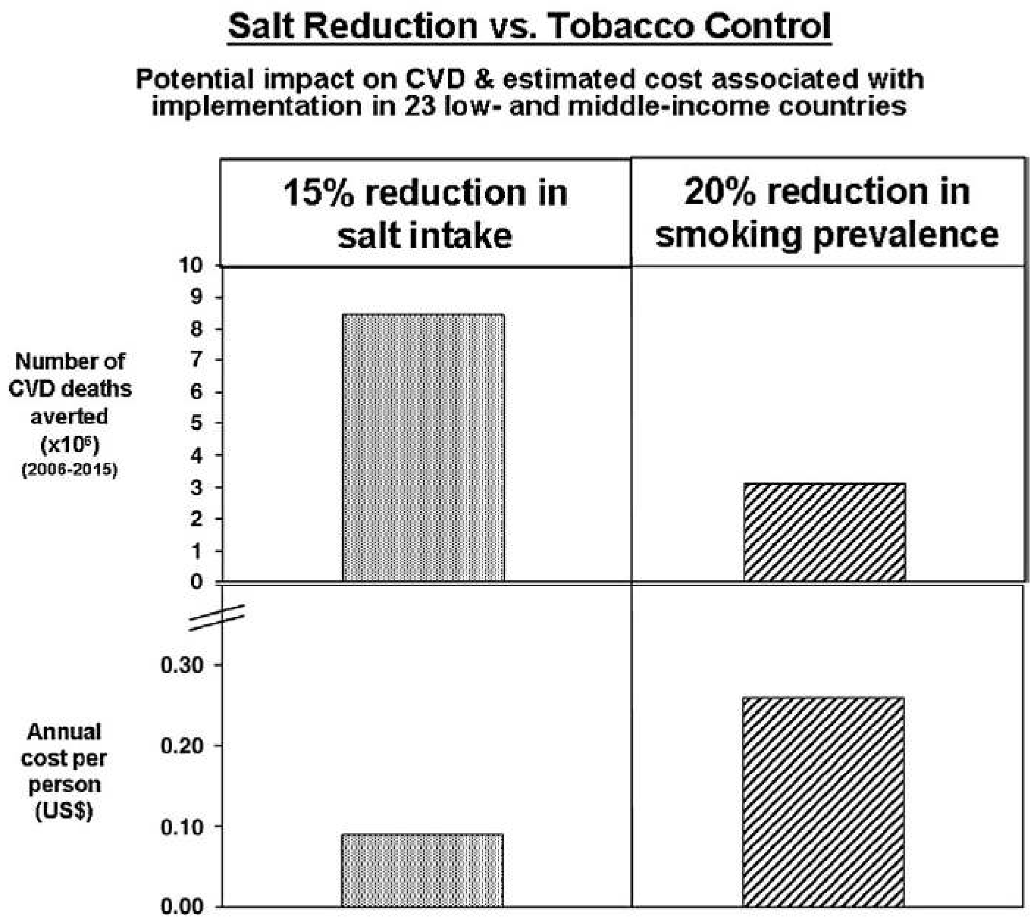


Fig 14. Number of CVD deaths averted and the financial costs associated with implementation of salt reduction and tobacco control in 23 low- and middle-income countries. Adapted from Asaria et al.[144]

취약계층 고려 필요성

표 2-IV-4. 고혈압 유병률[1] : 성별, 만30세이상, 사회경제적위치지표별, 2009

(단위 : %)

구분	전체				남자				여자			
	N	정상	고혈압전단계	고혈압	N	정상	고혈압전단계	고혈압	N	정상	고혈압전단계	고혈압
		분율(표준오차)	분율(표준오차)	분율(표준오차)		분율(표준오차)	분율(표준오차)	분율(표준오차)		분율(표준오차)	분율(표준오차)	분율(표준오차)
30세이상	4,862	41.4 (1.0)	26.7 (0.9)	31.9 (0.9)	2,078	32.6 (1.3)	32.3 (1.4)	35.1 (1.2)	2784	49.8 (1.3)	21.3 (0.9)	28.9 (1.2)
65세이상	1,304	14.0 (1.2)	21.0 (1.3)	64.9 (1.7)	540	18.1 (2.4)	21.7 (2.0)	60.2 (2.6)	764	11.3 (1.3)	20.5 (1.8)	68.2 (2.2)
연령(세)												
30-39	1,064	62.9 (1.9)	28.0 (1.9)	9.1 (1.1)	454	43.7 (3.2)	42.0 (3.1)	14.3 (2.0)	610	83.2 (1.8)	13.1 (1.6)	3.7 (0.9)
40-49	1,086	49.7 (1.8)	27.6 (1.5)	22.7 (1.6)	473	36.1 (2.9)	32.3 (2.2)	31.6 (2.6)	613	63.7 (2.0)	22.8 (2.0)	13.5 (1.7)
50-59	925	32.2 (2.1)	28.6 (2.0)	39.2 (1.8)	389	28.4 (2.8)	28.2 (2.9)	43.4 (3.0)	536	36.0 (2.8)	29.1 (2.8)	34.9 (2.4)
60-69	954	19.1 (1.4)	25.3 (1.5)	55.6 (1.8)	425	17.1 (1.8)	25.4 (2.4)	57.5 (2.5)	529	20.9 (1.9)	25.2 (2.1)	53.9 (2.8)
70+	833	11.6 (1.4)	19.0 (1.5)	69.5 (1.9)	337	16.5 (2.7)	20.7 (2.4)	62.8 (3.1)	496	8.6 (1.5)	17.9 (1.9)	73.6 (2.2)
거주지역												
동	3,301	43.5 (1.1)	25.9 (1.0)	30.5 (1.1)	1396	33.2 (1.5)	31.6 (1.7)	35.2 (1.5)	1905	53.3 (1.5)	20.5 (1.0)	26.1 (1.4)
읍면	1,561	34.7 (2.0)	29.0 (1.4)	36.4 (2.0)	682	30.8 (2.5)	34.4 (2.2)	34.8 (2.3)	879	38.5 (3.0)	23.5 (2.1)	37.9 (2.5)
소득수준[2]												
하	1,226	41.8 (1.9)	26.8 (1.6)	31.4 (1.6)	538	33.2 (2.5)	31.2 (2.4)	35.6 (2.2)	688	50.3 (2.7)	22.3 (2.2)	27.3 (2.1)
중하	1,221	39.0 (1.6)	27.8 (1.6)	33.2 (1.5)	518	32.2 (3.0)	33.3 (3.1)	34.5 (2.5)	703	45.8 (2.4)	22.2 (1.9)	32.0 (2.0)
중상	1,208	42.2 (2.4)	26.9 (1.9)	30.8 (2.0)	517	31.0 (3.0)	33.6 (3.1)	35.4 (2.9)	691	53.2 (2.9)	20.5 (1.9)	26.3 (2.3)
상	1,149	42.4 (2.0)	25.7 (2.0)	31.8 (1.8)	480	33.8 (3.0)	31.7 (3.3)	34.5 (2.6)	669	50.0 (1.8)	20.5 (1.5)	29.5 (2.1)
거주지역(표준화)[3]												
동	3,301	43.2 (1.0)	25.7 (0.9)	31.0 (0.9)	1396	32.4 (1.6)	31.0 (1.5)	36.6 (1.5)	1905	54.3 (1.1)	20.4 (1.1)	25.3 (1.0)
읍면	1,561	41.5 (1.7)	30.2 (1.7)	28.3 (1.0)	682	33.3 (2.4)	36.9 (2.3)	29.9 (1.7)	879	52.2 (2.2)	21.8 (2.2)	26.0 (1.4)
소득수준(표준화)												
하	1,226	42.5 (1.7)	26.8 (1.6)	30.7 (1.4)	538	33.1 (2.6)	31.0 (2.4)	35.8 (2.4)	688	52.5 (1.9)	22.3 (2.0)	25.2 (1.6)
중하	1,221	41.0 (1.7)	27.9 (1.7)	31.1 (1.4)	518	31.9 (2.8)	34.1 (2.9)	33.9 (2.4)	703	51.4 (1.8)	20.8 (1.8)	27.8 (1.7)
중상	1,208	42.7 (1.9)	27.0 (1.7)	30.3 (1.5)	517	30.7 (2.8)	33.4 (2.9)	35.9 (2.3)	691	55.5 (2.1)	20.3 (1.8)	24.2 (1.8)
상	1,149	45.3 (1.8)	26.1 (1.8)	28.6 (1.3)	480	34.5 (2.8)	32.3 (2.9)	33.2 (2.3)	669	55.4 (2.0)	20.7 (2.0)	23.9 (1.5)

1) 고혈압 유병률 : 수축기혈압이 140mmHg 이상이거나 이완기혈압이 90mmHg 이상 또는 혈압강하제를 복용한 분율, 만30세이상
고혈압 전단계 : 고혈압 유병자가 아니면서, 수축기혈압이 120-139mmHg이거나 이완기혈압이 80-89mmHg인 분율
※ 혈압 관련 결과는 잠정치로, 자료 추가 검토 후 재발표 예정

2) 소득수준 : 월가구균등화소득(월가구소득/$\sqrt{\text{가구원수}}$)을 성별 · 연령별(5세단위) 사분위로 분류

3) 2005년 추계인구로 연령표준화

소결

- 심혈관 사망과 소금섭취의 J shape의 가능성은 보다 면밀한 연구설계와 재연을 통해 향후 염분섭취의 타당한 기준을 만드는데 의의가 있을 수 있다.
- 그러나 국내의 높은 염분섭취 수준과, 이에 따른 건강영향의 확고한 근거를 통해 볼 때, 인구집단을 대상으로 한 염분섭취 제한에 대한 정책적 노력은 공중보건학적으로 타당하고 효과적이다.