

Citation:

Elliott P, Stamler J, Dyer AR, Appel L, Dennis B, Kesteloot H, Ueshima H, Okayama A, Chan Q, Garside DB, Zhou B for the Intermap Research Group. Association between protein intake and blood pressure. *Archives of Internal Medicine*, 2006; 166: 79-87.

PubMed ID: [16401814](#)

Study Design:

Cross-sectional study

Class:

D - [Click here](#) for explanation of classification scheme.

Research Design and Implementation Rating:

POSITIVE: See Research Design and Implementation Criteria Checklist below.

Research Purpose:

To study the association of vegetable, animal and total protein intake with blood pressure in a sample involving 17 diverse populations in four countries.

Inclusion Criteria:

Randomly selected samples of the populations

Exclusion Criteria:

- Failure to attend all four pre-study visits
- Providing unreliable diet data
- Calorie intake of less than 500kcal per day
- Calorie intake greater than 5,000 calories per day for women or 8,000 per day for men
- Unavailability of two consecutive urine samples
- Other incomplete or missing data.

Description of Study Protocol:**Recruitment**

None described.

Design

- Cross-sectional epidemiological study of 4,680 men and women aged 40 to 59 years from 17 distinct population groups in four countries
- Dietary intake based on 24-hour recall was recorded four times

- Two urine measurements of sodium, potassium, urea, creatinine, calcium and magnesium were taken
- Demographic and confounding data were obtained during interviews and recorded on questionnaires.

Blinding Used

Not applicable, except to ensure quality control of data collection and laboratory analysis of urine samples.

Intervention

None.

Statistical Analysis

- Associations among nutritional variables were explored with partial correlational analysis
- Multiple-regression analysis was used to examine associations between individuals' vegetable, animal and total protein intake and blood pressure
- ANCOVA was used to adjust for country, age and sex.

Data Collection Summary:

Timing of Measurements

- Blood pressure was measured twice on two consecutive days at baseline and three to six weeks later (eight measurements total).
- All foods, beverages and supplements consumed in the previous 24 hours were recorded; four recalls per person were obtained.

Dependent Variables

- Systolic blood pressure
- Diastolic blood pressure.

Independent Variables

- Animal protein intake
- Vegetable protein intake
- All foods, beverages and supplements consumed in the previous 24 hours were recorded; four recalls per person were obtained.

Control Variables

Five models were established to account for:

1. Sample, age, and gender difference
2. #1 plus adjustment for special diet, history of cardiovascular disease or diabetes mellitus, family history of hypertension, moderate or heavy physical activity and dietary supplement intake
3. #2 plus adjustment for 24-hour urinary sodium and potassium excretion and seven-day alcohol intake
4. #3 plus adjustment for calcium, saturated fatty acid, polyunsaturated fatty acid and dietary cholesterol intake

- 5. #4 plus adjustment for dietary magnesium intake
- 6. #5 plus adjustment for fiber intake.

Description of Actual Data Sample:

- Initial N: 4,895
- Attrition (final N): 4,680.

Age

- Japan: 49.4±5.3 years
- The People's Republic of China: 49.0±5.8
- United Kingdom: 49.1±5.6
- United States: 49.1±5.4.

Ethnicity

Not specified.

Anthropometrics

- Height (in meters) was 1.61±0.09 in Japan, 1.59±0.08 in the People's Republic of China, 1.69±0.09 in the United Kingdom and 1.68±0.10 in the United States
- Weight (in kilograms) was 61.2±10.2 in Japan, 58.9±10.0 in the Peoples Republic of China, 78.2±15.3 in the United Kingdom and 82.3±19.6 in the United States.

Location

Japan, the People's Republic of China, the United Kingdom and the United States.

Summary of Results:

Table. Estimated Blood Pressure Differences Associated with 2-SDs Higher Vegetable Protein Intake with 2-SDs Higher Animal Protein Intake

Model	Systolic Blood Pressure				Diastolic Blood Pressure			
	Unadjusted for Height and Weight		Adjusted for Height and Weight		Unadjusted for Height and Weight		Adjusted for Height and Weight	
	Difference, mm Hg	Z-Score	Difference, mm Hg	Z-Score	Difference, mm Hg	Z-Score	Difference, mm Hg	Z-Score
Vegetable Protein Intake								
1	-2.72†	-6.81‡	-1.95	-5.10‡	-1.67	-6.20‡	-1.22	-4.67‡
2	-2.88†	-6.88‡	2.05	-5.08‡	-1.73	-6.11‡	-1.23	-4.47†
3	-2.14†	-4.99‡	-1.11	-2.67§	-1.35	-4.61‡	-0.71	-2.48?
4	-1.70	-3.44‡	-0.90	-1.90	-1.11	-3.30‡	-0.63	-1.93
5a	-1.23	-2.07?	-0.95	-1.67	-1.22	-3.02§	-1.03	-2.65†
5b	-1.29	-2.05?	-1.01	-1.68	-1.12	-2.64§	-0.95	-2.32?
Animal Protein Intake								

1	1.55	3.76‡	0.31	0.78	0.68	2.41?	-0.07	-0.25
2	1.23	3.02§	0.15	0.39	0.59	2.12?	-0.06	-0.27
3	1.03	2.53?	0.20	0.51	0.49	1.76	-0.02	-0.07
4	1.15	2.27?	0.26	0.53	0.78	2.23?	0.24	0.70
5a	1.28	2.52?	0.32	0.65	0.85	2.42?	0.26	0.76
5b	0.96	1.88	0.22	0.44	0.70	1.97?	0.25	0.73

* Variables were added sequentially in the models per the “Statistical Analysis” subsection of the “Methods” section. Values of two SDs of vegetable and animal protein are given in the “Results” section

† Test of homogeneity significant at $P < 0.05$

‡ $P < 0.001$

§ $P < 0.01$

? $P < 0.05$

Key Findings

- After adjusted for confounders (age, gender, special diet, CVD, diabetes mellitus, family history of hypertension, physical activity, dietary supplement, adjustment for urinary sodium and potassium excretion, and seven day alcohol intake), BP differences associated with higher vegetable protein intake of 2.8% kilocalories were -2.14 mm Hg systolic and -1.35 mm Hg diastolic ($p < 0.001$ for both); after further adjustment for height and weight, these differences were -1.11 mm Hg systolic ($p < 0.01$) and -0.71 mm Hg diastolic ($p < 0.05$).
- After adjusted for confounders, there was a significant, direct association between higher animal protein intake (by 2SD equal to 5.84% kilocalories) and systolic and diastolic blood pressure. However, adjusted for height and weight, the blood pressure differences were non-significant.

Other Findings

- Vegetable protein intake and animal protein intake (adjusted for sample, age and sex) were inversely correlated ($R = -0.36$)
- High correlations were found between vegetable protein intake and total fiber intake ($R = 0.64$), between vegetable protein intake and dietary magnesium intake ($R = 0.56$), between animal protein intake and cholesterol intake ($R = 0.55$) and between dietary magnesium intake and total fiber intake ($R = 0.71$).

Author Conclusion:

- Found an inverse relationship between individuals' vegetable protein intake and their blood pressure
- Did not confirm previous epidemiological findings of an inverse relationship between total protein intake and blood pressure.

Reviewer Comments:

- *Authors note variation in dietary assessment methods and variation among food tables in different countries.*

Research Design and Implementation Criteria Checklist: Primary Research

Relevance Questions

- | | | |
|----|---|-----|
| 1. | Would implementing the studied intervention or procedure (if found successful) result in improved outcomes for the patients/clients/population group? (Not Applicable for some epidemiological studies) | Yes |
| 2. | Did the authors study an outcome (dependent variable) or topic that the patients/clients/population group would care about? | Yes |
| 3. | Is the focus of the intervention or procedure (independent variable) or topic of study a common issue of concern to nutrition or dietetics practice? | Yes |
| 4. | Is the intervention or procedure feasible? (NA for some epidemiological studies) | Yes |

Validity Questions

- | | | |
|------|---|-----|
| 1. | Was the research question clearly stated? | Yes |
| 1.1. | Was (were) the specific intervention(s) or procedure(s) [independent variable(s)] identified? | Yes |
| 1.2. | Was (were) the outcome(s) [dependent variable(s)] clearly indicated? | Yes |
| 1.3. | Were the target population and setting specified? | Yes |
| 2. | Was the selection of study subjects/patients free from bias? | Yes |
| 2.1. | Were inclusion/exclusion criteria specified (e.g., risk, point in disease progression, diagnostic or prognosis criteria), and with sufficient detail and without omitting criteria critical to the study? | Yes |
| 2.2. | Were criteria applied equally to all study groups? | Yes |
| 2.3. | Were health, demographics, and other characteristics of subjects described? | Yes |
| 2.4. | Were the subjects/patients a representative sample of the relevant population? | N/A |
| 3. | Were study groups comparable? | Yes |
| 3.1. | Was the method of assigning subjects/patients to groups described and unbiased? (Method of randomization identified if RCT) | N/A |
| 3.2. | Were distribution of disease status, prognostic factors, and other factors (e.g., demographics) similar across study groups at baseline? | Yes |
| 3.3. | Were concurrent controls used? (Concurrent preferred over historical controls.) | N/A |

3.4.	If cohort study or cross-sectional study, were groups comparable on important confounding factors and/or were preexisting differences accounted for by using appropriate adjustments in statistical analysis?	Yes
3.5.	If case control or cross-sectional study, were potential confounding factors comparable for cases and controls? (If case series or trial with subjects serving as own control, this criterion is not applicable. Criterion may not be applicable in some cross-sectional studies.)	N/A
3.6.	If diagnostic test, was there an independent blind comparison with an appropriate reference standard (e.g., "gold standard")?	N/A
4.	Was method of handling withdrawals described?	Yes
4.1.	Were follow-up methods described and the same for all groups?	Yes
4.2.	Was the number, characteristics of withdrawals (i.e., dropouts, lost to follow up, attrition rate) and/or response rate (cross-sectional studies) described for each group? (Follow up goal for a strong study is 80%.)	Yes
4.3.	Were all enrolled subjects/patients (in the original sample) accounted for?	Yes
4.4.	Were reasons for withdrawals similar across groups?	Yes
4.5.	If diagnostic test, was decision to perform reference test not dependent on results of test under study?	N/A
5.	Was blinding used to prevent introduction of bias?	Yes
5.1.	In intervention study, were subjects, clinicians/practitioners, and investigators blinded to treatment group, as appropriate?	N/A
5.2.	Were data collectors blinded for outcomes assessment? (If outcome is measured using an objective test, such as a lab value, this criterion is assumed to be met.)	Yes
5.3.	In cohort study or cross-sectional study, were measurements of outcomes and risk factors blinded?	Yes
5.4.	In case control study, was case definition explicit and case ascertainment not influenced by exposure status?	N/A
5.5.	In diagnostic study, were test results blinded to patient history and other test results?	N/A
6.	Were intervention/therapeutic regimens/exposure factor or procedure and any comparison(s) described in detail? Were intervening factors described?	Yes
6.1.	In RCT or other intervention trial, were protocols described for all regimens studied?	N/A
6.2.	In observational study, were interventions, study settings, and clinicians/provider described?	Yes

6.3.	Was the intensity and duration of the intervention or exposure factor sufficient to produce a meaningful effect?	Yes
6.4.	Was the amount of exposure and, if relevant, subject/patient compliance measured?	N/A
6.5.	Were co-interventions (e.g., ancillary treatments, other therapies) described?	N/A
6.6.	Were extra or unplanned treatments described?	N/A
6.7.	Was the information for 6.4, 6.5, and 6.6 assessed the same way for all groups?	Yes
6.8.	In diagnostic study, were details of test administration and replication sufficient?	N/A
7.	Were outcomes clearly defined and the measurements valid and reliable?	Yes
7.1.	Were primary and secondary endpoints described and relevant to the question?	N/A
7.2.	Were nutrition measures appropriate to question and outcomes of concern?	Yes
7.3.	Was the period of follow-up long enough for important outcome(s) to occur?	Yes
7.4.	Were the observations and measurements based on standard, valid, and reliable data collection instruments/tests/procedures?	Yes
7.5.	Was the measurement of effect at an appropriate level of precision?	Yes
7.6.	Were other factors accounted for (measured) that could affect outcomes?	Yes
7.7.	Were the measurements conducted consistently across groups?	Yes
8.	Was the statistical analysis appropriate for the study design and type of outcome indicators?	Yes
8.1.	Were statistical analyses adequately described and the results reported appropriately?	Yes
8.2.	Were correct statistical tests used and assumptions of test not violated?	Yes
8.3.	Were statistics reported with levels of significance and/or confidence intervals?	Yes
8.4.	Was "intent to treat" analysis of outcomes done (and as appropriate, was there an analysis of outcomes for those maximally exposed or a dose-response analysis)?	Yes
8.5.	Were adequate adjustments made for effects of confounding factors that might have affected the outcomes (e.g., multivariate analyses)?	Yes
8.6.	Was clinical significance as well as statistical significance reported?	Yes

8.7.	If negative findings, was a power calculation reported to address type 2 error?	N/A
9.	Are conclusions supported by results with biases and limitations taken into consideration?	Yes
9.1.	Is there a discussion of findings?	Yes
9.2.	Are biases and study limitations identified and discussed?	Yes
10.	Is bias due to study's funding or sponsorship unlikely?	Yes
10.1.	Were sources of funding and investigators' affiliations described?	Yes
10.2.	Was the study free from apparent conflict of interest?	Yes

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