# Associations of body fat, sodium intake, and selenium intake with blood pressure in adult men: a cross-sectional study

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**Abstract.** Hypertension is a major cardiovascular risk; its regulation involves multiple modifiable factors, including adiposity and micronutrient intake. Evidence on how body fat percentage (BF), sodium, and selenium influence blood pressure (BP) in rural Indonesian men is limited and inconclusive. This study aims to analyze the association of BF, sodium intake, and selenium intake with BP in adult men. A cross-sectional study was conducted, involving 73 adult men (age 21−34**)** from Sukajadi Village, Bogor District, West Java. BP was measured with a calibrated sphygmomanometer following standardized protocol. BF was assessed by Bio Impedance Analysis (Inbody 270). Sodium and selenium intakes were estimated using a semi-quantitative food frequency questionnaire (SQ-FFQ). Spearman rank correlation was used to assess associations. The mean body fat percentage (BF%) was 11.34±7.15%, classified as low BF. Sodium intake averaged 2,133.9±876.34 mg/day, and selenium intake averaged 48.7±22.24 µg/day. BF% was significantly correlated with systolic blood pressure ($p<0.05$), whereas selenium intake was significantly correlated with diastolic blood pressure ($p<0.05$). The results highlight the potential importance of adiposity and micronutrient intake in BP regulation. Longitudinal studies in larger and more diverse populations are needed to establish causality and clarify mechanisms linking these modifiable factors to BP regulation and long-term cardiovascular outcomes.

## 1 Introduction

Non-Communicable Diseases (NCDs) have been a major challenge in the health sector, significantly impairing productivity and disrupting daily activities. NCDs are the leading cause of death worldwide, responsible for over 43 million deaths in 2021 [1]. In Indonesia, cardiovascular diseases remain a significant NCD subtype; as of 2019, they accounted for 375.479 deaths, with 69% attributed to hypertension [2], underscoring the urgent regional burden.

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Hypertension, a major cardiovascular disease, is characterized by persistently elevated blood pressure above normal levels (typically ≥130/80 mmHg). It is influenced by several factors including genetics, environment, and hemodynamic regulation [3]. Visceral fat provides incremental prediction of hypertension risk beyond BMI, as visceral adiposity promotes neurohumoral activation and inflammation. Dietary sodium intake is a well-established modifiable determinant of blood pressure. Meanwhile, dietary selenium intake shows an inverse linear association with hypertension prevalence, with higher intake linked to a lower risk across diverse U.S. adults (e.g., prevalence 40.3% in lowest quartile vs. 32.2% in highest) [4]. This study focuses on early adult men from Sukajadi Village to reduce gender-related confounding and to address BP variation in early adulthood. Therefore, the study includes sodium intake as a primary independent variable, alongside BF and selenium intake, to assess their independent and combined associations with BP in a rural Indonesian male population.

## 2 Materials and method

### 2.1. Study design and samples

This study employed the cross-sectional design, involving 73 adult men (age 21−34) in Sukajadi Village, Tamansari Sub-district, Bogor District, West Java. The data were obtained from a longitudinal study entitled "*Growth of rural children in West Java, Indonesia: a twenty-year follow-up study*." This study obtained ethical approval from the Bogor Agricultural University Research Ethics Committee Involving Human Subjects number 271/IT3.KEPMSM-IPB/SK/2020.

### 2.2 Outcome measures

Percentage body fat (BF) was categorized as Low (<16%BW), Normal (16−31% BW), High (31-35% BW) and Obese (>35% BW) [5]. Sodium intake was divided into two categories i.e. Normal (≤2,000 mg) and Excessive (>2,000 mg) [6]. Selenium intake was categorized relative to the recommended dietary allowance (RDA) of 55 µg/day for adolescents: low (<80% RDA), normal (80–120% RDA), and excessive (>120% RDA) [7]. Meanwhile, blood pressure (BP) was categorized as follows: optimal (systolic <120 mmHg and diastolic <80 mmHg), normal (systolic 120–129 mmHg or diastolic 80–84 mmHg), high-normal (systolic 130–139 mmHg or diastolic 85–89 mmHg), hypertension stage I (systolic 140–159 mmHg or diastolic 90–99 mmHg), and hypertension stage II (systolic ≥160 mmHg and diastolic ≥100 mmHg) [8].

### 2.3 Data collection

BF was measured using bioelectrical impedance analysis (BIA Inbody 270). Sodium and selenium intake were assessed using a semi quantitative food frequency (SQ-FFQ) questionnaire administered by a trained enumerator. Food quantities were estimated using household measures and food models, and intake values were calculated using the Indonesian Food Composition Table. Blood pressure was measured using a calibrated mercury sphygmomanometer by trained health personnel, following a reproducible and rigorous protocol. Two measurements were taken and averaged, if necessary.

### 2.4 Data analysis

Descriptive statistics were calculated for all variables. Normality was assessed using the Kolmogorov-Smirnov test. Spearman rank correlation was used to examine pairwise associations between BF, sodium intake, selenium intake, and BP (systolic and diastolic). Correlations with $p<0.05$ were considered statistically significant.

## 3 Result and discussion

### 3.2 Sodium and selenium intake

Selenium intake was predominantly excessive in subjects (89.1%), with the remainder classified as normal (2.7) and low (8.2%) (Table 1). This high intake likely stems from frequent consumption of selenium-rich foods abundant in rural West Java diets, such as seafood, poultry, eggs, and vegetables like onions and garlic.

The average sodium intake exceeded the recommendation (2,133.89±876.34 mg/day), surpassing the Permenkes No. 30/2013 limit of <2,000 mg sodium/day. This aligns with national patterns where Indonesian sodium intake often exceeds WHO/Permenkes (IMH) thresholds, contributing to hypertension risk in rural populations [9].

### 3.3 Body fat percentage (BF)

As shown in Table 1, the majority of subjects were classified as having low BF, and mean BF was 11.3±7.2%, falling within the low category. Low body fat composition may compromise endocrine and metabolic functions, including reduced leptin production, impaired thermoregulation, and potential effects on growth and pubertal development [10].

**Table 1.** Sodium and selenium intake, classification of nutritional status, body fat percentage and blood pressure of subjects.

| Variables | n | % |
|---|---|---|
| Sodium Intake | | |
| Excessive (>2,000 mg/day) | 40 | 54.8 |
| Normal (≤2,000 mg/day) | 33 | 45.2 |
| Mean±SD (mg) | 2133.89±876.34 | |
| Selenium | | |
| Excessive (>120% RDA) | 65 | 89.1 |
| Normal (80−120% RDA) | 2 | 2.7 |
| Low (<80% RDA) | 6 | 8.2 |
| Mean±SD (% RDA) | 84.56±50.25 | |
| Nutritional status (BMI) | | |
| Severely underweight (<17 kg/m$^2$) | 4 | 5.5 |
| Underweight (17−18.4 kg/m$^2$) | 18 | 24.7 |
| Normal (18.5−25.0 kg/m$^2$) | 41 | 56.2 |
| Overweight (25.1−.0 kg/m$^2$) | 2 | 2.7 |
| Obese (>27 kg/m$^2$) | 8 | 11 |
| Mean±SD (kg/m$^2$) | 21.2±3.9 | |
| Body fat percentage | | |
| Low (<16% BW) | 59 | 80.8 |
| Normal (16−31% BW) | 12 | 16.4 |
| High (31−35% BW) | 1 | 1.4 |

| | | |
|---|---|---|
| Obese (>35% BW) | 1 | 1.4 |
| Mean±SD (%BW) | 11.3±7.2 | |
| Systolic | | |
| Optimal (<120 mmHg) | 57 | 78.1 |
| Normal (120−129 mmHg) | 11 | 15.1 |
| Normal high (130−139 mmHg) | 3 | 4.1 |
| Hypertension I (140−159 mmHg) | 1 | 1.4 |
| Hypertension II (160−179 mmHg) | 1 | 1.4 |
| Mean±SD (mmHg) | 108±11.6 | |
| Diastolic | | |
| Optimal (<80 mmHg) | 41 | 56.2 |
| Normal (80−84 mmHg) | 28 | 38.4 |
| Normal high (85−89 mmHg) | 0 | 0 |
| Hypertension I (90−99 mmHg) | 3 | 4.1 |
| Hypertension II (100−109 mmHg) | 1 | 1.4 |
| Mean±SD (mmHg) | 74±7.2 | |

### 3.3. Associations of blood pressure with sodium intake and selenium intake

Mean Systolic Dan Diastolic Blood Pressure (SBP) of subjects were within the normal range per ACC/AHA guidelines. Sodium and selenium intake play an important role in hypertension as modifiable factors [11].

Sodium intake was not significantly correlated with systolic or diastolic blood pressure (Table 2). Sodium intake has no clinical manifestation on blood pressure, considering that the respondents were still in early adulthood and mostly normotensive. This finding is consistent with [12]: meta-analyses of randomized controlled trials (RCTs) have shown that dietary sodium reduction has a negligible effect on blood pressure in normotensive individuals.

**Table 2.** Correlation analysis of selenium intake, body fat percentage and blood pressure of subjects.

| **Variables** | **Blood pressure[1)]** | |
|---|---|---|
| | **Systolic** | **Diastolic** |
| Sodium intake | 0.097 (0.412) | 0.175 (0.138) |
| Selenium intake | 0.160 (0.176) | 0.233 (0.047)* |
| Body fat mass | 0.237 (0.043)* | 0.168 (0.155) |

[1)]r (p-value), *significant at p<0.05

In contrast, selenium intake was significantly associated with diastolic BP ($p<0.05$); however, a meta-analysis [13] found mixed evidence, with only 5 of 10 studies reporting a positive correlation between selenium and BP. Excessive selenium intake may elevate hypertension risk by upregulating aldosterone expression, thereby reducing urinary sodium excretion and increasing blood pressure.

### 3.4 Association between blood pressure (BP) and body fat percentage (BF)

Systolic blood pressure was significantly correlated with body fat ($p<0.05$). This finding is consistent with prior research reporting a positive association between body fat mass in men and blood pressure. High BF alters lipoprotein metabolism, characterized by elevated triglycerides (TG), reduced HDL cholesterol, and normal or slightly increased LDL

cholesterol. Such lipid changes, combined with obesity-induced chronic inflammation from elevated cytokines and reduced adiponectin, promote endothelial dysfunction and increase risks of hypertension and atherosclerosis [14, 15].

## 4 Conclusions and implications

In this rural cross-sectional study of Indonesian men, body fat was associated with systolic blood pressure (BP), whereas selenium intake was associated with diastolic BP. Sodium intake was not significantly related to either BP outcome; however, this should not be interpreted as evidence that sodium is harmless. These findings suggest that adiposity and micronutrient intake may contribute to BP regulation. Further longitudinal and interventional studies with comprehensive confounder adjustment are needed to clarify causality, define optimal intake ranges, and elucidate potential mechanisms, including oxidative stress, endothelial function, and fluid balance.

## References

1. [WHO] World Health Organization, World health statistics 2018: monitoring health for the SDGs, sustainable development goals (World Health Organization, Geneva 2018).
2. Institute for Health Metrics and Evaluation, Global burden of 369 diseases and injuries in 204 countries and territories 1990–2019: a systematic analysis for the Global Burden of disease study 2019. Lancet. **396**, 1204–1222 (2020). https://doi.org/10.1016/S0140-6736(20)30925-9
3. N.M. Kaplan, Primary hypertension: pathogenesis (Lippincot Williams & Wilkins, Philadelphia, 2010).
4. Y. Wu, Z. Yu, Association between dietary selenium intake and the prevalence of hypertension: results from the National Health and Nutrition Examination Survey 2003−2018. Front. Immunol. **15**, 1338745 (2024). https://doi.org/10.3389/fimmu.2024.1338745
5. M.M. Rahman, N.A. Salikunna, Sumarni, R.D. Wahyuni, R. Badaruddin, M.Z. Ramadhan, A. Arief, Hubungan asupan lemak terhadap persentase lemak tubuh mahasiswa fakultas kedokteran Universitas Tadulako angkatan 2019. Healthy Tadulako Journal. **7**, 1 (2021).
6. [IMH] Indonesian Ministry of Health (Kemenkes RI). Pedoman gizi seimbang (Kementerian Kesehatan RI, Jakarta, 2014).
7. [IMH] Indonesian Ministry of Health (Kemenkes RI). Peraturan menteri kesehatan RI Nomor 28 Tahun 2019 tentang angka kecukupan gizi yang dianjurkan untuk masyarakat Indonesia (Kementerian Kesehatan RI, Jakarta, 2019).
8. [IMH] Indonesian Ministry of Health (Kemenkes RI). Keputusan menteri kesehatan RI Nomor HK.01.07/MENKES/4634/2021 tentang pedoman nasional pelayanan kedokteran tatalaksana hipertensi dewasa (Kementerian Kesehatan RI, Jakarta, 2021).
9. S. Prihatini, D. Permaesih, D. Julianti, Asupan natrium penduduk Indonesia: analisis data survei konsumsi makanan individu (SKMI) 2014. Giz. Ind. **39**, 1 (2016). https://doi.org/10.36457/gizindo.v39i1.205
10. P.B. Maffetone, I. Rivera-Dominguez, P.B. Laursen, Overfat and underfat: new terms and definitions long overdue. Front. Public Health. **4**, 279 (2017). https://doi.org/10.3389/fpubh.2016.00279
11. H. Khodadadi, A. Ebrahimi, F. Jalali, A.F. Ardakani, Z. Hajhashemy, G. Askari, Dose-

response association between circulating selenium and blood pressure: a systematic review and meta-analysis. BMC Public Health. **25**, 3986 (2025). https://doi.org/10.1186/s12889-025-24205-x

12. N. Graudal, T. Hubeck-Graudal, G. Jürgens, R.S. Taylor, Dose-response relation between dietary sodium and blood pressure: a meta-regression analysis of 133 randomized controlled trials. Am. J. Clin. Nutr. **109** (2019). https://doi.org/10.1093/ajcn/nqy384
13. P. Tang, R. Huang, X. Zhong, X. Chen, Y. Lei, A comprehensive review on selenium and blood pressure: Recent advances and research perspectives. J. JTEMB. **88**, 127607 (2025). https://doi.org/10.1016/j.jtemb.2025.127607
14. P.E. Korhonen, T. Mikkola, H. Kautiainen, J.G. Eriksson, Both lean and fat body mass associate with blood pressure. Eur. J. Internal. Medicine. **91** (2021). https://doi.org/10.1016/j.ejim.2021.04.025
15. J. Sun, Z. Zhang, Z. Liu, W. Kang, The Correlation of total percent fat with alterations in cholesterol and triglycerides in adults. Front. Nutr. **9**, 881729 (2022).https://doi.org/10.3389/fnut.2022.881729