Prospective Clinical Research Report

Journal of INTERNATIONAL MEDICAL RESEARCH

Journal of International Medical Research
49(5) 1–9

DOI: 10.1177/03000605211010051
journals.sagepub.com/home/imr
SAGE

Association of the Geriatric Nutritional Risk Index with incident hypertension in the older Chinese population: a 6-year cohort study

Zhongjian Su*, Xing Zhang*, Nan Zheng, Ying Xiao, Xingzhu Liu, Yanfei Yang, Lili Deng, Yanfei Chen and Bin Li

Abstract

Background: We examined the association of the Geriatric Nutritional Risk Index (GNRI) with the incidence of hypertension.

Methods: We used data of the China Health and Nutrition Survey in this study. Participants aged $\geq$60 years were eligible. The GNRI was defined as follows: GNRI = [1.489 × albumin (ALB; g/L)] + [41.7 × (actual weight/ideal weight)]. Participants with systolic blood pressure $\geq$140 mmHg, diastolic blood pressure $\geq$90 mmHg, or use of antihypertensive medication were defined as having hypertension.

Results: This study included 4853 participants, comprising 3612 control participants and 1241 participants with hypertension. The GNRI, ALB, and body mass index (BMI) were significantly associated with higher incidence of hypertension (HR: 1.030, 1.026, and 1.088; 95% CI: 1.020–1.041, 1.008–1.044, and 1.069–1.107, respectively). The GNRI, ALB, and BMI were associated with an earlier age of hypertension onset ($\beta = -0.403$, -0.613, and -0.321; 95% CI: -0.493 to -0.314, -0.767 to -0.459, and -0.484 to -0.159, respectively).

Conclusions: A higher GNRI was associated with increased incidence of hypertension. An elevated GNRI was associated with earlier age of hypertension onset.

Keywords

Geriatric Nutritional Risk Index, incidence, hypertension, serum albumin, older people, China

Date received: 13 December 2021; accepted: 24 March 2021

*These authors contributed equally to this work.

Corresponding author:
Bin Li, Kunming Children's Hospital, 288 Qianxing Road, Xishan District, Kunming, Yunnan Province 650034, China.
Email: libin@etyy.cn

Department of Cardiovascular Medicine, Kunming Children's Hospital, Kunming, Yunnan Province, China

Introduction

As a common chronic disease, hypertension is a major public health problem and the greatest attributable risk factor for death worldwide.[1] It is also a major modifiable risk factor for cardiovascular disease (CVD) and accounts for approximately 45% of global CVD morbidity and mortality.[2,3] Recently, there has been a sustained increase in the prevalence of hypertension globally. The current prevalence of hypertension is approximately 25% among adults and is expected to reach 29% by 2025, equating to approximately 1.55 billion people.[4,5] In China, the prevalence of hypertension among adults has increased rapidly, from 14.5% in 1991 to 34.0% in 2012.[6,7] It is imperative to identify the exact risk factors for hypertension in the Chinese population.

Nutritional status has drawn increasingly greater attention in settings where older people are currently the fastest-growing segment of the population and with greater adoption of a Western lifestyle. Nutritional risk has also been identified as an independent predictor of functional status and mortality.[8] Body mass index (BMI), serum albumin (ALB) level, and prealbumin (PA) levels are the most commonly used indexes to clinically evaluate nutritional status.[9] However, these single indexes have limited clinical application. Recently, a variety of complex nutritional indicators has been developed. The Geriatric Nutritional Risk Index (GNRI) is one of the most commonly used nutritional indicators.[10] There are a wealth of studies reporting the associations of the GNRI and ALB with the risks of hypertension, cardiovascular disease mortality, and all-cause mortality.[11–13] However, the conclusions of these studies have been inconsistent, especially for hypertension.

The aim of this study was to examine the association of the GNRI with the incidence of hypertension, based on the China Health and Nutrition Survey (CHNS). The results of this study will provide insightful and accurate evidence, to clarify the association of the GNRI with hypertension.

Patients and methods

Study design

This study was based on the CHNS, which covers 15 provinces that vary considerably in their geography, economic development, public resources, and health indicators. A multistage random cluster process was used to select four counties in each province. Villages and townships within the counties were selected randomly. The samples were diverse, with variation in a wide-ranging set of socioeconomic factors (income, employment, education, and urbanization) and other related health, nutritional, and demographic measures. A detailed description of the survey design and procedures has been published elsewhere.[14] This study was approved by the Institutional Review Board of the National Institute for Nutrition and Food Safety, China Center for Disease Control and Prevention, and the University of North Carolina at Chapel Hill (CHNS-2009-15). All participants provided their written informed consent.

Study population

Data were obtained from the latest three waves of the CHNS conducted from 2009 to 2015. The inclusion criteria were as follows: participants aged $\geq$60 years at baseline; participants with available data on sex and a detailed physical examination (e.g., weight and height); and participants without hypertension at baseline. The exclusion criteria were: participants who were pregnant or lactating at the time of the survey; and participants with missing or

implausible outlying data (e.g., weight >300 kg or <20 kg).

Measurements

This study was based on the CHNS, and we followed the detailed protocols of physical measurements including weight, height, and blood pressure as in a previous study by Zhao et al.,[15] which are provided in the CHNS.

In the 2009 survey, overnight fasting blood samples were collected from participants aged ≥60 years. Measures of triglycerides (TG), total cholesterol (TC), high density lipoprotein (HDL) cholesterol, low density lipoprotein (LDL) cholesterol, fasting plasma glucose, and ALB were obtained using an automated biochemistry analyzer (Hitachi 7600; Randox Laboratories, Ltd., Crumlin, UK and Kyowa Medex Co. Ltd., Tokyo, Japan) in a Beijing central laboratory.

During follow up, the end-event was identified as participants being diagnosed with hypertension, which was defined as systolic blood pressure (SBP) ≥140 mmHg, DBP ≥90 mmHg, or use of antihypertensive medication.[16,17] Estimated glomerular filtration rate (eGFR) was calculated using the Chronic Kidney Disease Epidemiology Collaboration equation: $eGFR = 141 \times \min(Scr/\kappa, 1)^{\alpha} \times \max(Scr/\kappa, 1)^{-1.209} \times 0.993^{age} \times 1.018$ [if female] $\times 1.159$ [if black], where Scr is serum creatinine, κ is 0.7 for female sex and 0.9 for male sex, α is -0.329 for female sex and -0.411 for male sex, min indicates the minimum of Scr/κ or 1, and max indicates the maximum of Scr/κ or 1.[18]

The GNRI was calculated as follows: GNRI= [1.489×ALB (g/L)]+[41.7× (actual weight/ideal weight)].[19] The ideal weight was calculated using the Lorentz formula.[19] If weight/ideal weight was greater than 1, weight/ideal weight was set to 1.

Statistical analysis

Data are presented as mean ± standard deviation for continuous variables and frequency (percentage) for categorical variables. Baseline characteristics were compared between the non-hypertension and hypertension groups using a *t*-test for continuous variables and chi-square tests for categorical variables. Cox regression was conducted to obtain the hazard ratio (HR) and 95% confidential interval (CI) with hypertension as the end-event, and further stratified by sex and residential area. All Cox models met the proportional hazards assumption. To correct the competing risks of death for hypertension, all models were adjusted for death. Linear regression was used to analyze the effects of the GNRI on the age at onset of hypertension. In the adjusted models, age, sex, smoking, drinking, ethnicity, educational level, physical activity, diabetes history, cardiovascular history, TC, TG, LDL, HDL, blood glucose, and eGFR at baseline were adjusted. All analyses were conducted using SAS 9.4 (SAS Institute Inc., Cary, NC, USA.), with two-tailed $P \leq 0.05$ considered to indicate statistical significance.

Results

This study included 4853 participants, comprising 3612 participants without hypertension and 1241 participants with hypertension. The median follow-up duration was 4.47 years. The average participant age was 67.69 years, and BMI was 22.86 kg/m^2. Baseline characteristics were compared between the non-hypertension and hypertension groups. There were significant differences in all characteristics except age, HDL, and cardiovascular disease history (Table 1).

Table 2 shows the associations of nutritional status with the incidence of hypertension in Cox regression. When adjusted for

Table 1. Comparison of baseline characteristics between subgroups.

Characteristics	All participants (4853)	Subgroups		*P*-value
		No hypertension (3612)	Hypertension (1241)	
Age (years)[a]	67.69 ± 6.47	67.54 ± 6.74	67.91 ± 6.03	0.361
BMI (kg/m^2)[a]	22.86 ± 3.22	22.56 ± 3.12	23.75 ± 3.32	<0.001
TG (mmol/L)[a]	1.57 ± 1.40	1.52 ± 1.41	1.70 ± 1.34	<0.001
TC (mmol/L)[a]	4.79 ± 0.97	4.73 ± 0.96	4.96 ± 0.98	<0.001
LDL (mmol/L)[a]	2.93 ± 0.95	2.88 ± 0.92	3.06 ± 1.00	<0.001
HDL (mmol/L)[a]	1.45 ± 0.43	1.45 ± 0.43	1.44 ± 0.44	0.614
GLU (mmol/L)[a]	5.28 ± 1.31	5.21 ± 1.24	5.48 ± 1.47	<0.001
eGFR (mL/minute per 1.73 m^2)[a]	83.92 ± 14.58	85.20 ± 14.52	80.21 ± 14.13	<0.001
GNRI[a]	110.38 ± 5.88	110.17 ± 5.86	111.01 ± 5.90	<0.001
Sex				0.001
Male	2195 (45.23)	1584 (43.85)	611 (49.23)	
Female	2658 (54.77)	2028 (56.15)	630 (50.77)	
Education level				<0.001
Primary school or none	1954 (40.31)	1336 (37.05)	618 (49.80)	
Middle school	2641 (54.49)	2067 (57.32)	574 (46.25)	
College or above	252 (5.20)	203 (5.63)	49 (3.95)	
Smoking				0.004
No	3373 (69.50)	2551 (70.63)	822 (66.24)	
Yes	1480 (30.50)	1061 (29.37)	419 (33.76)	
Drinking				0.001
No	3281 (67.61)	2488 (68.88)	793 (63.90)	
Yes	1572 (32.39)	1124 (31.12)	448 (36.10)	
Ethnicity				0.019
Han	4249 (87.55)	3139 (86.90)	1110 (89.44)	
Other[b]	604 (12.45)	473 (13.10)	131 (10.56)	
Physical activity				<0.001
No	4407 (90.81)	3248 (89.92)	1159 (93.39)	
Yes	446 (9.19)	364 (10.08)	82 (6.61)	
Diabetes history				<0.001
No	4308 (88.77)	3268 (90.48)	1040 (83.80)	
Yes	545 (11.23)	344 (9.52)	201 (16.20)	
Cardiovascular disease history				1.000
No	4836 (99.65)	3599 (99.64)	1237 (99.68)	
Yes	17 (0.35)	13 (0.36)	4 (0.32)	

Values are mean ± standard deviation or frequency (percentage).

[a]These variables were analyzed using the *t*-test.

[b]Indicates 55 other ethnic minorities, including Hui, Manchu, Zhuang, and Mongolian.

BMI: body mass index, TG: triglyceride, TC: total cholesterol, LDL: low-density lipoprotein, HDL: high-density lipoprotein, GLU: blood glucose, eGFR: estimated glomerular filtration rate, GNRI: Geriatric Nutritional Risk Index.

covariates, the GNRI, ALB, and BMI were significantly associated with a higher incidence of hypertension ($P < 0.001$, $P = 0.005$, and $P < 0.001$; HR 1.030, 1.026, and 1.088; and 95% CI 1.020–1.041, 1.008–1.044, and 1.069–1.107, respectively). When the associations of nutritional status with the incidence of hypertension were analyzed

Table 2. Association of nutritional status with incidence of hypertension in Cox regression.

	Crude[a]			Adjusted[b]		
Model	*P*-value	HR	95% CI	*P*-value	HR	95% CI
Model 1						
GNRI	<0.001	1.019	1.010–1.029	<0.001	1.030	1.020–1.041
Model 2						
ALB	0.478	1.006	0.989–1.023	0.005	1.026	1.008–1.044
Model 3						
BMI	<.001	1.090	1.073–1.108	<0.001	1.088	1.069–1.107

[a]In the crude model, death was adjusted.

[b]In the adjusted model, age, sex, smoking, drinking, ethnicity, education level, physical activity, diabetes history, cardiovascular history, triglyceride, total cholesterol, low-density lipoprotein, high-density lipoprotein, blood glucose, estimated glomerular filtration rate, and death were adjusted.

GNRI: Geriatric Nutritional Risk Index, ALB: albumin, BMI: body mass index, HR: hazard ratio, CI: confidence interval.

in men and women separately, results of the GNRI and BMI were consistent with those in the total population. ALB was associated with a higher incidence of hypertension in women ($P = 0.039$) but not in men. When stratified by residential area, positive associations of the GNRI, ALB, and BMI with the incidence of hypertension were observed with both rural and urban residence (Table 3).

The associations of nutritional status with the age at onset of hypertension are displayed in Table 4. With and without adjustment for covariates, the GNRI, ALB, and BMI were associated with an earlier age at hypertension onset (all adjusted $P < 0.010$; $\beta = -0.403$, -0.613, and -0.321; and 95% CI: -0.493 to -0.314, -0.767 to -0.459, and -0.484 to -0.159, respectively). In both men and women, the results were consistent with those in the total population. Stratified by residential area, the results were comparable with those in the total population, except for BMI with urban residence.

Discussion

This study was based on the CHNS and aimed to examine the associations of nutritional status with the incidence of hypertension in a 6-year cohort study. The results implied that the GNRI was associated with higher incident hypertension in both men and women, as well as in rural and urban residents. Similarly, as elements of the GNRI, the results for ALB and BMI paralleled the GNRI. Furthermore, a higher GNRI was associated with earlier age at hypertension onset.

In this study, the GNRI was significantly associated with a higher incidence of hypertension, which was consistent with a previous study.[20] As the GNRI is calculated using ALB and BMI, the effects of the GNRI on risk of hypertension might be explained by ALB and BMI. Many studies have reported a consistent positive association of ALB with blood pressure, which was also confirmed in this study.[21,22] With the blood volume expansion and tryptophan-binding effects of ALB, higher ALB will result in a greater blood volume, which in turn increases blood pressure. Furthermore, this association was in accordance with the important role ALB exerts in regulating the colloid osmotic pressure.[23] The ALB rates of synthesis and degradation/excretion and distribution between intra- and extravascular compartments determine the ALB

Table 3. Association of nutritional status with incidence of hypertension in Cox regression, stratified by sex and residential area

	Crude[a]			Adjusted[b]		
Model	*P*-value	HR	95% CI	*P*-value	HR	95% CI
Men (N = 2192)						
GNRI	0.036	1.014	1.001–1.028	<0.001	1.027	1.012–1.042
ALB	0.487	0.992	0.968–1.016	0.212	1.017	0.991–1.044
BMI	<0.001	1.085	1.06–1.112	<0.001	1.090	1.062–1.119
Women (N = 2654)						
GNRI	0.001	1.023	1.009–1.038	<0.001	1.030	1.015–1.045
ALB	0.234	1.015	0.991–1.039	0.039	1.027	1.001–1.053
BMI	<0.001	1.097	1.072–1.122	<0.001	1.084	1.059–1.111
Rural (N = 3371)						
GNRI	<0.001	1.025	1.013–1.038	<0.001	1.025	1.013–1.038
ALB	0.882	1.001	0.982–1.021	0.045	1.022	1.001–1.043
BMI	<0.001	1.073	1.053–1.094	<0.001	1.073	1.051–1.096
Urban (N = 1475)						
GNRI	<0.001	1.046	1.025–1.068	<0.001	1.046	1.025–1.068
ALB	0.227	1.021	0.987–1.055	0.027	1.041	1.005–1.079
BMI	<0.001	1.135	1.102–1.170	<0.001	1.120	1.085–1.157

[a]In the crude model, death was adjusted.

[b]In the adjusted model stratified by sex, age, smoking, drinking, ethnicity, education level, physical activity, diabetes history, cardiovascular history, triglyceride, total cholesterol, low-density lipoprotein, high-density lipoprotein, blood glucose, estimated glomerular filtration rate, and death were adjusted. In adjusted model stratified by residential area, age, sex, smoking, drinking, ethnicity, education level, physical activity, diabetes history, cardiovascular history, triglyceride, total cholesterol, low-density lipoprotein, high-density lipoprotein, blood glucose, estimated glomerular filtration rate and death were adjusted.

GNRI: Geriatric Nutritional Risk Index, ALB: albumin, BMI: body mass index, HR: hazard ratio, CI: confidence interval.

concentration. If hydrostatic pressure in the vessels rises beyond the critical point, plasma ALB will be forced out of the vascular space, which will in turn increase extra-vascular osmotic pressure. Thus, more body fluid will flow into the vessels to increase blood pressure. Previous data suggest that a change per 10 g/L in serum ALB is associated with an increase of 17 mmHg and 9 mmHg in SBP and DBP in older people, respectively.[21] Therefore, participants with a lower GNRI and lower ALB levels were not susceptible to having hypertension.

The GNRI is related to weight. As a major risk factor of hypertension, elevated weight is associated with an increased incidence of hypertension.[24,25] As a result, a higher GNRI owing to elevated weight could promote the development of hypertension. As secondary proof, the results of ALB and BMI further confirmed that the associations of the GNRI with incident hypertension were feasible.

Strengths and limitations

This study was based on the CHNS, a national and prospective population-based survey. A 6-year cohort study was used to examine the association of nutritional status with the incidence of hypertension; therefore, the associations would be close to a causal relationship. Furthermore,

Table 4. Association of nutritional status with age at onset of hypertension.

	Crude[a]			Adjusted[b]		
	β	*P*-value	95% CI	β	*P*-value	95% CI
Total						
GNRI	−0.513	<0.001	−0.628 to −0.399	−0.403	<0.001	−0.493 to −0.314
ALB	−0.740	<0.001	−0.942 to −0.539	−0.613	<0.001	−0.767 to −0.459
BMI	−0.586	<0.001	−0.791 to −0.380	−0.321	<0.001	−0.484 to −0.159
Men (N = 611)						
GNRI	−0.732	<0.001	−0.896 to −0.569	−0.645	<0.001	−0.808 to −0.482
ALB	−1.131	<0.001	−1.424 to −0.837	−0.974	<0.001	−1.257 to −0.692
BMI	−0.851	<0.001	−1.175 to −0.528	−0.617	<0.001	−0.943 to −0.290
Women (N = 630)						
GNRI	−0.264	0.001	−0.421 to −0.107	−0.373	<0.001	−0.521 to −0.226
ALB	−0.291	0.036	−0.564 to −0.019	−0.498	<0.001	−0.754 to −0.242
BMI	−0.402	0.002	−0.661 to −0.143	−0.480	<0.001	−0.724 to −0.236
Rural (N= 931)						
GNRI	−0.486	<0.001	−0.615 to −0.356	−0.508	<0.001	−0.633 to −0.383
ALB	−0.676	<0.001	−0.907 to −0.445	−0.722	<0.001	−0.942 to −0.502
BMI	−0.696	<0.001	−0.933 to −0.458	−0.654	<0.001	−0.886 to −0.422
Urban (N= 310)						
GNRI	−0.649	<0.001	−0.890 to −0.408	−0.536	<0.001	−0.772 to −0.299
ALB	−0.976	<0.001	−1.388 to −0.564	−0.744	<0.001	−1.138 to −0.350
BMI	−0.388	0.067	−0.804 to 0.027	−0.353	0.086	−0.757 to 0.050

[a]In the crude model, death was adjusted.

[b]In the total adjusted model, rural and urban residence, sex, smoking, drinking, ethnicity, education level, physical activity, diabetes history, cardiovascular history, triglyceride, total cholesterol, low-density lipoprotein, high-density lipoprotein, blood glucose, estimated glomerular filtration rate, and death were adjusted. In the male and female adjusted model, smoking, drinking, ethnicity, education level, physical activity, diabetes history, cardiovascular history, triglyceride, total cholesterol, low-density lipoprotein, high-density lipoprotein, blood glucose, estimated glomerular filtration rate, and death were adjusted.

GNRI: Geriatric Nutritional Risk Index, ALB: albumin, BMI: body mass index, CI: confidence interval.

ALB and BMI were used to additionally examine the association of the GNRI with risk of hypertension, thereby providing a more convincing association of the GNRI with incidence of hypertension. However, several limitations of this study should be noted. First, data on dietary intake were unavailable in the CHNS. As a result, the relevant nutrients failed to be adjusted in the analyses. Second, only the history of myocardial infarction was recorded rather than histories of all cardiovascular diseases. Therefore, the confounding effect of cardiovascular diseases failed to be fully corrected. Third, as family history of cardiovascular disease and hypertension were not collected in the CHNS, these failed to be included and adjusted in this study.

Conclusions

The GNRI was positively associated with the incidence of hypertension in both men and women, as well as in individuals with either rural or urban residence. Furthermore, an elevated GNRI was associated with an earlier age at onset of hypertension.

Acknowledgments

This research used data from China Health and Nutrition Survey (CHNS). We thank the National Institute for Nutrition and Health, China Center for Disease Control and Prevention, Carolina Population Center, the University of North Carolina at Chapel Hill, the NIH and the NIH Fogarty International Center for the CHNS data collection.

Declaration of conflicting interest

The authors declare that there is no conflict of interest.

Funding

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by the Kunming Health Personnel Training Project (2017-sw (backup) – 105, 2017-sw (backup) – 109).

ORCID iD


Bin Li https://orcid.org/0000-0003-3888-1352

References

1. Attard SM, Herring AH, Zhang B, et al. Associations between age, cohort, and urbanization with systolic and diastolic blood pressure in China: a population-based study across 18 years. *J Hypertens* 2015; 33: 948–956.
2. Ezzati M, Vander Hoorn S, Lawes CM, et al. Rethinking the "diseases of affluence" paradigm: global patterns of nutritional risks in relation to economic development. *PLoS Med* 2005; 2: e133.
3. Gac P, Poreba M, Mazur G, et al. The aortic mechanical properties in patients with the essential hypertension environmentally exposed to cigaret smoke. *Inhal Toxicol* 2015; 27: 717–723. DOI: 10.3109/08958378.2015.1103337.
4. Mittal BV and Singh AK. Hypertension in the developing world: challenges and opportunities. *Am J Kidney Dis* 2010; 55: 590–598. DOI: 10.1053/j.ajkd.2009.06.044.
5. Kearney PM, Whelton M, Reynolds K, et al. Global burden of hypertension: analysis of worldwide data. *Lancet* 2005; 365: 217–223. DOI: 10.1016/S0140-6736(05)17741-1.
6. Wang J, Zhang L, Wang F, et al. Prevalence, awareness, treatment, and control of hypertension in China: results from a national survey. *Am J Hypertens* 2014; 27: 1355–1361. DOI: 10.1093/ajh/hpu053.
7. Li D, Lv J, Liu F, et al. Hypertension burden and control in mainland China: analysis of nationwide data 2003–2012. *Int J Cardiol* 2015; 184: 637–644.
8. Cereda E, Pedrolli C, Zagami A, et al. Nutritional risk, functional status and mortality in newly institutionalised elderly. *Br J Nutr* 2013; 110: 1903–1909. DOI: 10.1017/S0007114513001062.
9. Sun X, Luo L, Zhao X, et al. Controlling Nutritional Status (CONUT) score as a predictor of all-cause mortality in elderly hypertensive patients: a prospective follow-up study. *BMJ Open* 2017; 7: e015649.
10. Cereda E and Pedrolli C. The use of the Geriatric Nutritional Risk Index (GNRI) as a simplified nutritional screening tool. *Am J Clin Nutr* 2008; 87: 1966–1967.
11. Nishi I, Seo Y, Hamada-Harimura Y, et al. Geriatric nutritional risk index predicts all-cause deaths in heart failure with preserved ejection fraction. *ESC Heart Fail* 2019; 6: 396–405. DOI: 10.1002/ehf2.12405.
12. Oda E. Decreased serum albumin predicts hypertension in a Japanese health screening population. *Intern Med* 2014; 53: 655–660. DOI: 10.2169/internalmedicine.53.1894.
13. Djousse L, Rothman KJ, Cupples LA, et al. Serum albumin and risk of myocardial infarction and all-cause mortality in the Framingham Offspring Study. *Circulation* 2002; 106: 2919–2924. DOI: 10.1161/01.cir.0000042673.07632.76.
14. Popkin BM, Du S, Zhai F, et al. Cohort Profile: The China Health and Nutrition Survey—monitoring and understanding socio-economic and health change in China, 1989–2011. *Int J Epidemiol* 2010; 39: 1435–1440.
15. Zhao R, Duan X, Wu Y, et al. Association of exposure to Chinese famine in early life

with the incidence of hypertension in adulthood: A 22-year cohort study. *Nutr Metab Cardiovasc Dis* 2019; 29: 1237–1244.
16. Chobanian AV. Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure; National Heart, Lung, and Blood Institute; National High Blood Pressure Education Program Coordinating Committee: Seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. *Hypertension* 2003; 42: 1206–1252.
17. Chobanian AV, Bakris GL, Black HR, et al. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 report. *JAMA* 2003; 289: 2560–2572. DOI: 10.1001/jama.289.19.2560.
18. Levey AS, Stevens LA, Schmid CH, et al. A new equation to estimate glomerular filtration rate. *Ann Intern Med* 2009; 150: 604–612. DOI: 10.7326/0003-4819-150-9-200905050-00006.
19. Bouillanne O, Morineau G, Dupont C, et al. Geriatric Nutritional Risk Index: a new index for evaluating at-risk elderly medical patients. *Am J Clin Nutr* 2005; 82: 777–783. DOI: 10.1093/ajcn/82.4.777.
20. Matsuo Y, Kumakura H, Kanai H, et al. The Geriatric Nutritional Risk Index Predicts Long-Term Survival and Cardiovascular or Limb Events in Peripheral Arterial Disease. *J Atheroscler Thromb* 2020; 27: 134–143. DOI: 10.5551/jat.49767.
21. Hostmark AT, Tomten SE and Berg JE. Serum albumin and blood pressure: a population-based, cross-sectional study. *J Hypertens* 2005; 23: 725–730. DOI: 10.1097/01.hjh.0000163139.44094.1d.
22. Hu H, Sparrow D and Weiss S. Association of serum albumin with blood pressure in the normative aging study. *Am J Epidemiol* 1992; 136: 1465–1473. DOI: 10.1093/oxfordjournals.aje.a116467.
23. Nicholson JP, Wolmarans MR and Park GR. The role of albumin in critical illness. *Br J Anaesth* 2000; 85: 599–610. DOI: 10.1093/bja/85.4.599.
24. Chen Y, Liang X, Zheng S, et al. Association of Body Fat Mass and Fat Distribution With the Incidence of Hypertension in a Population-Based Chinese Cohort: A 22-Year Follow-Up. *J Am Heart Assoc* 2018; 7: e007153. DOI: 10.1161/JAHA.117.007153.
25. Rahmouni K, Correia ML, Haynes WG, et al. Obesity-associated hypertension: new insights into mechanisms. *Hypertension* 2005; 45: 9–14. DOI: 10.1161/01.HYP.0000151325.83008.b4.