

## Original Article

# *The Relationship Between Body Mass Index and Blood Pressure in Vietnam*

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### ABSTRACT

**Background:** The relationship between body mass index (BMI) and blood pressure in the Vietnamese population has not been clearly defined. This study aims to examine the clinical characteristics and BMI of hypertensive patients and investigate the relationship between BMI and blood pressure.

**Methods:** This study employs a cross-sectional descriptive design and random sampling. Participants' blood pressure was measured 3 times using an automatic sphygmomanometer.

**Results:** A total of 5910 individuals participated in the study, with 2138 being diagnosed with hypertension. Among the participants, 20.8% were overweight, 20.8% were obese, and 9.9% were underweight. Linear regression analysis demonstrated a positive correlation between BMI and systolic blood pressure in both sexes (men:  $r = 0.339$ ,  $P < 0.05$ ; women:  $r = 0.324$ ,  $P < 0.05$ ; overall:  $r = 0.345$ ,  $P < 0.05$ ). After adjustments for age and gender, a 1-unit increase in BMI corresponded to a 1.414 mm Hg increase in systolic blood pressure. Obesity and overweight were associated with an increased risk of hypertension compared with normal weight (OR, 1.91; 95% CI, 1.67 to 2.18;  $P < 0.05$  and OR, 1.81; 95% CI, 1.58 to 2.07;  $P < 0.05$ , respectively). Conversely, being underweight was associated with a reduced risk of hypertension (OR, 0.34; 95% CI, 0.27 to 0.43;  $P < 0.05$ ).

**Conclusions:** The study found a positive correlation between BMI and blood pressure. It is advisable to manage weight even in individuals without hypertension and utilize BMI as a tool for detecting hypertension within the community. (*Iranian Heart Journal 2025; 26(1): 6-15*)

**KEYWORDS:** Body mass index, Blood pressure, Hypertension, Vietnam

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Hypertension (HTN) is a critical global public health concern, including in Vietnam. Epidemiological studies in Vietnam have shown an increasing trend in hypertension rates, from 28.7% in 2017 to 33.8% in 2019.<sup>1,2</sup> Alongside economic and

social development in the country, obesity rates have been rising in the Vietnamese population. Between 2009 and 2015, the prevalence of obesity increased from 0.8% to 10% in men and from 1.7% to 16.4% in women.<sup>3</sup> Obesity (body mass index [BMI]  $\geq$

35 kg/m<sup>2</sup>) is a significant risk factor for hypertension, contributing to the worsening of cardiovascular events.<sup>4</sup> While age and sex are known risk factors for hypertension, they are unchangeable. In contrast, obesity is a modifiable risk factor. Long-term weight loss has been shown to effectively reduce blood pressure and lower the risk of hypertension, even with minimal weight loss.<sup>5</sup> Research indicates that obesity (BMI  $\geq$  30 kg/m<sup>2</sup>) in young individuals is strongly linked to the prevalence of hypertension (hazard ratio: 4.17; 95% CI, 2.34 to 7.42).<sup>6</sup> Obesity increases hypertension risk through various mechanisms, including overactivity of the sympathetic nervous system, activation of the renin-angiotensin-aldosterone system, alterations in adipose-derived cytokines, insulin resistance, structural and functional changes in the kidneys, and other obesity-associated factors.<sup>7</sup>

BMI is a widely used anthropometric index for assessing obesity due to its simplicity and ease of implementation. It can be readily incorporated into community health screening programs. The May Measure Month (MMM) program, initiated by the International Society of Hypertension (ISH), aims to raise awareness about hypertension as a global health concern. By utilizing BMI as a screening tool, MMM can help identify individuals at risk for hypertension and promote the importance of managing modifiable risk factors, such as obesity, to reduce the overall burden of hypertension. In light of the MMM program, this study aimed to contribute to the understanding of the relationship between BMI and hypertension. With this objective in mind, we conducted the current research with the following goals:

1. Examine the clinical characteristics and BMI of hypertensive individuals.
2. Investigate the correlation between BMI and blood pressure.

## METHODS

From May 2023 through August 2023, this descriptive, cross-sectional study recruited individuals 18 years and older via random sampling. Informed consent was obtained from all participants.

Qualitative variables, including sex, and quantitative variables, including age (y), weight (kg), height (cm), systolic blood pressure (SBP) (mm Hg), and diastolic blood pressure (DBP) (mm Hg) were measured 3 times.

Participants' weight was measured using an electronic scale, and height was determined using a ruler by trained medical personnel. Before the measurements, participants were asked to remove their shoes, clothing, and any additional items.

BMI was calculated utilizing the following formula:

$$\text{BMI} = \text{weight (kg)} / (\text{height [m]})^2 \text{ (kg/m}^2\text{)}$$

The BMI classification in this study was based on the World Health Organization (WHO) assessment guidelines specific to Asian populations (2000)<sup>8</sup>:

1. Underweight: BMI < 18.5 kg/m<sup>2</sup>
2. Normal weight: BMI = 18.5–22.9 kg/m<sup>2</sup>
3. Overweight: BMI = 23–24.9 kg/m<sup>2</sup>
4. Obese: BMI  $\geq$  25 kg/m<sup>2</sup>

Prior to blood pressure measurement, all screening participants were instructed to abstain from smoking, consuming coffee, and engaging in physical exercise for at least 30 minutes. Additionally, they were asked to sit and relax for 3 to 5 minutes before the measurement was taken.<sup>9</sup>

Blood pressure was measured using an automated sphygmomanometer in accordance with the MMM 2023 protocol.<sup>10</sup>

Hypertension was defined as either having a previously documented history of hypertension and receiving treatment or

exhibiting an SBP of  $\geq 140$  mm Hg and/or a DBP of  $\geq 90$  mm Hg. These criteria were based on the guidelines set forth by the Vietnam Society of Hypertension/Vietnam National Heart Association (VSH/VNHA) in 2022<sup>11</sup> and the ISH in 2020.<sup>9</sup> The mean SBP and the mean DBP were determined by calculating the average of the second and third measurements for both SBP and DBP.<sup>10</sup>

### Statistical Analysis

Statistical analysis of all data was performed using IBM SPSS Statistics 26.0 software. Categorical variables were presented as frequencies, while continuous variables were expressed as mean values with standard deviations. The comparison of 2 means was conducted using the *t*-test, while categorical variables were analyzed using the  $\chi^2$  test at a 95% confidence level ( $P < 0.05$ ). For further exploration of the relationship between BMI and blood pressure, linear regression analysis was conducted using BMI and SBP/DBP data. Subsequently, a graphical representation of the relationship between BMI and SBP/DBP was generated.

Additionally, logistic regression was employed to calculate the odds ratio (OR) for increased blood pressure in the overweight and obese subgroups, as determined by BMI, compared with the normal-weight group. This analysis was performed with a 95% confidence interval

(95% CI), and statistical significance was defined as a *P* value of  $< 0.05$ .

Multivariable linear regression was utilized to estimate the mean SBP difference per unit increase in BMI. This analysis also incorporated age and sex as additional variables to account for their potential influence on SBP. Consequently, regression equations for SBP were developed based on age, sex, and BMI.

## RESULTS

### 1. Clinical characteristics and BMI of hypertensive patients

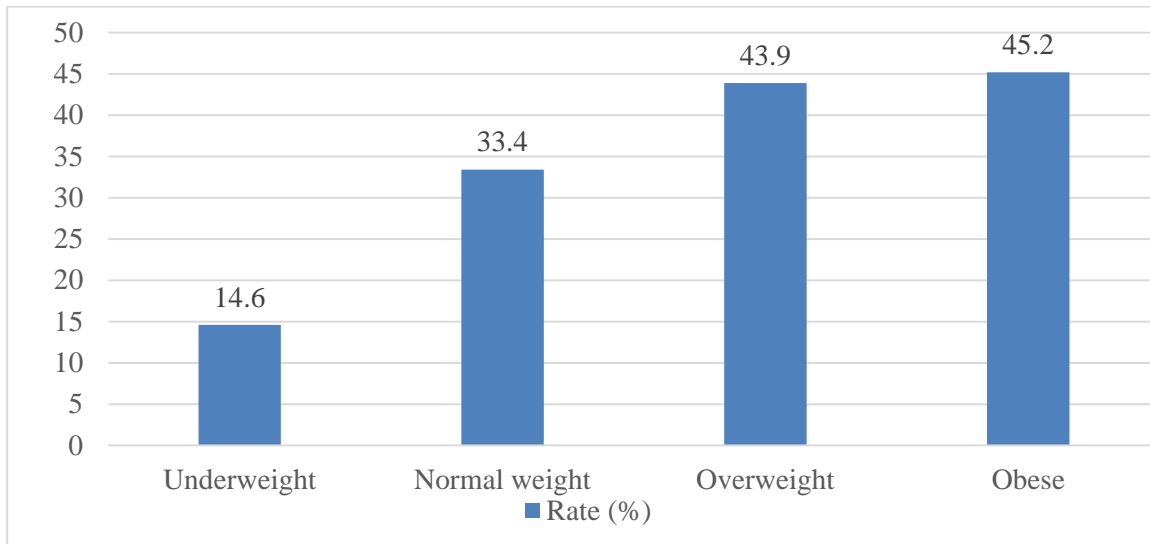
Our study involved blood pressure screening in 5910 adults in Vietnam, yielding the following results. Among the participants, 2138 individuals were diagnosed with hypertension. The mean age of the hypertensive population was  $52.0 \pm 15.2$  years, and the average BMI was  $22.7 \pm 3.7$  kg/m<sup>2</sup> (Table 1). Among the screened participants, the prevalence of overweight and obesity was 20.8%, while 9.9% were classified as underweight (Table 2). Further analysis revealed a statistically significant difference in hypertension rates across BMI subgroups. The highest hypertension rate was observed in the obese group at 45.2%, while the lowest rate was found in the underweight group at 14.6% (Fig. 1).

**Table 1:** General Characteristics of the Research Subjects

Characteristics	Total (n=5910)	Hypertension (n=2138)	No Hypertension (n=3772)	<i>P</i>
Age, y	52.0 $\pm$ 15.2	60.1 $\pm$ 12.2	48.0 $\pm$ 15.0	< 0.001
Sex				
Male, n (%)	2984 (46.0)	1056 (49.4)	1928 (44.3)	< 0.001
Female n (%)	3510 (54.0)	1082 (50.6)	2428 (55.7)	
Mean systolic blood pressure, mm Hg	125.1 $\pm$ 17.4	141.5 $\pm$ 17.0	117.1 $\pm$ 10.7	< 0.001
Mean diastolic blood pressure, mm Hg	76.16 $\pm$ 16.1	83.2 $\pm$ 9.8	72.7 $\pm$ 7.6	< 0.001
Body mass index, kg/m <sup>2</sup>	22.7 $\pm$ 3.7	23.5 $\pm$ 3.7	22.2 $\pm$ 3.6	< 0.001

**Table 2:** Relationships Between Body Mass Index Subgroups and Hypertension

Body Mass Index Subgroup	Hypertension				Total		P
	Yes		No		n	%	
	n	%	n	%			
Underweight	85	1.4	499	8.4	584	9.9	< 0.001
Normal weight	958	16.2	1910	32.3	2868	48.5	
Overweight	540	9.1	690	11.7	1230	20.8	
Obese	555	9.4	673	11.4	1228	20.8	
Total	2138	36.2	3772	63.8	5910	100	



**Figure 1:** The image illustrates the distribution of the hypertension rate according to body mass index subgroups.

**2. Relationship between BMI and blood pressure**

Our study revealed a higher proportion of overweight/obese individuals in the hypertensive group than in the non-hypertensive group. A significant association between BMI subgroups and hypertension was observed ( $P < 0.05$ ) (Table 2). Moreover, there was an increase in both SBP and DBP across the BMI subgroups, with a statistically significant difference (Fig. 2). SBP exhibited a significant and linear increase with rising BMI. The mean SBP demonstrated an increase of  $> 8$  mm Hg from the normal BMI subgroup to the obese subgroup. Notably, the highest mean SBP was observed in the obese subgroup at  $132.3 \pm 20.6$  mm Hg, followed by the normal BMI subgroup at  $123.6 \pm 16.6$  mm Hg, and the

lowest mean SBP was found in the underweight subgroup at  $112.4 \pm 13.9$  mm Hg (Fig. 2). Linear regression analysis was conducted to further investigate the relationship between BMI and SBP. Figures 3a, 3b, and 3c demonstrate a statistically significant correlation between BMI and SBP. A strong positive correlation was observed between BMI and blood pressure in the overall population ( $r = 0.339$ ,  $P < 0.05$ ), as well as in men ( $r = 0.324$ ,  $P < 0.05$ ) and women ( $r = 0.345$ ,  $P < 0.05$ ) when analyzed separately. Figures 4a, 4b, and 4c reveal a weak positive correlation between BMI and DBP. The correlation coefficients ( $r$ ) were 0.193, 0.171, and 0.200 for the combined sexes, men, and women, respectively ( $P < 0.05$ ) (Fig. 4). As shown in Table 3, the equation for estimating SBP based on age, BMI, and sex is as follows:

$$SBP = 70.876 + 0.402 (\text{age}) + 1.414 (\text{BMI}) + 3.240 (\text{sex})$$

This equation indicates that for every 1-year increase in age, SBP increases by 0.402 mm Hg. Additionally, for every 1 kg/m<sup>2</sup> increase in BMI, SBP rises by 1.414 mm Hg. Furthermore, SBP for men is 3.240 mm Hg higher than that for women.

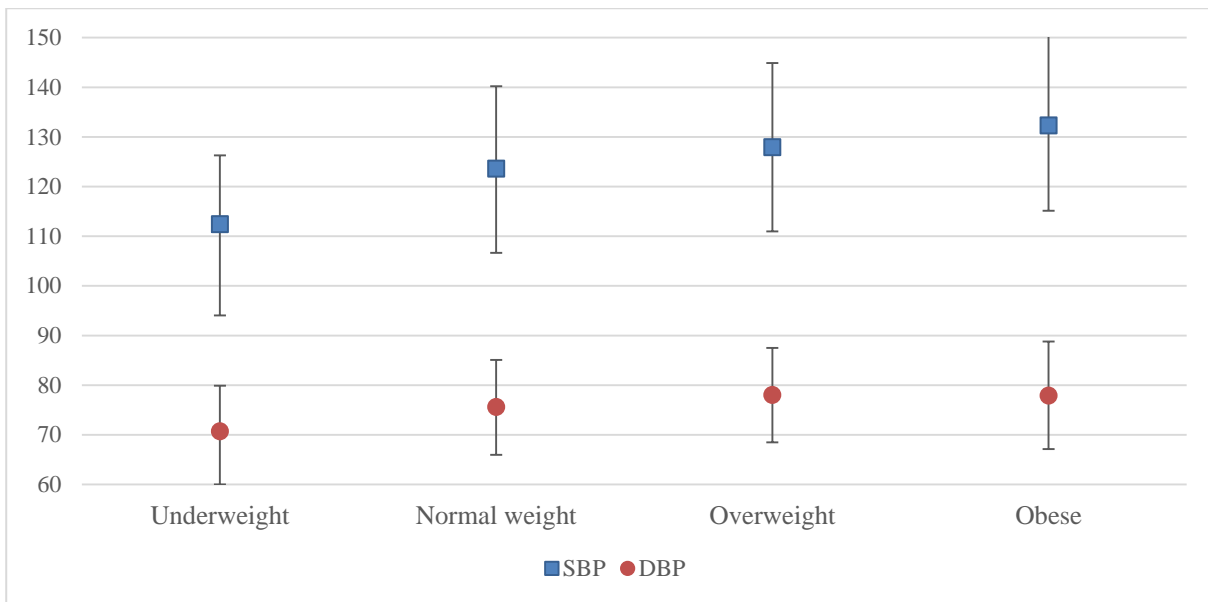
According to Table 4, the equation for estimating DBP based on age, BMI, and sex is as follows:

$$DBP = 57.829 + 0.149 (\text{age}) + 0.420 (\text{BMI}) + 2.244 (\text{sex})$$

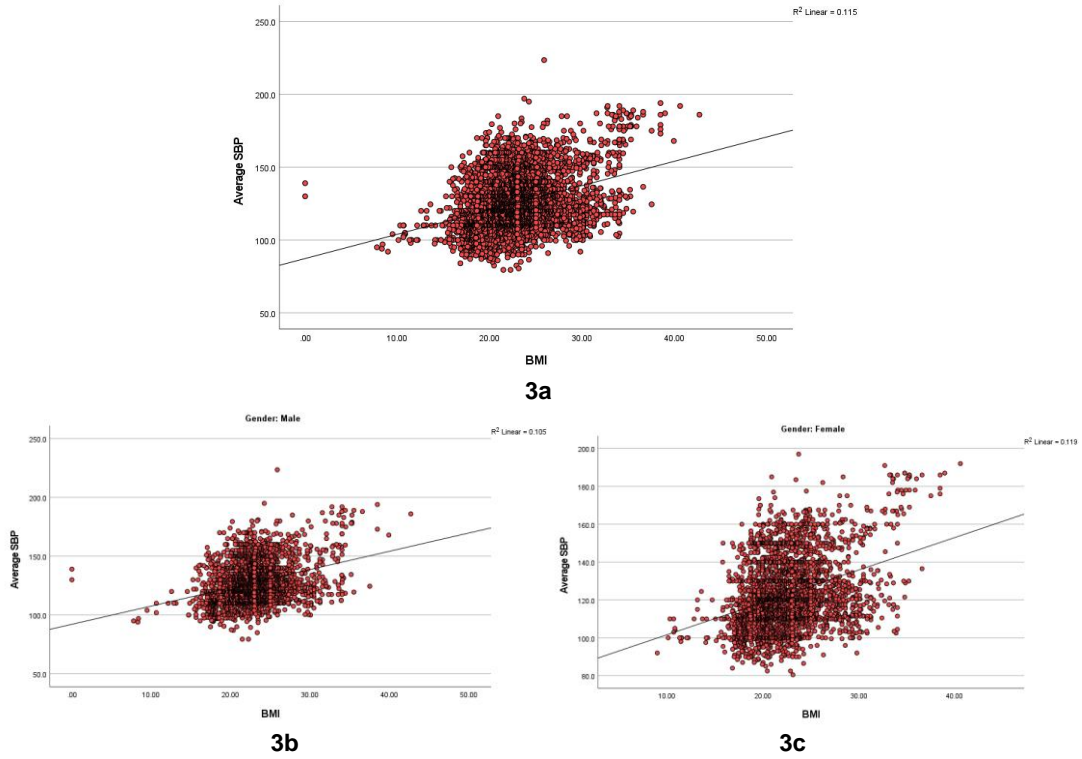
This equation demonstrates that for every 1-year increase in age, the DBP rises by 0.149 mm Hg. Moreover, for every 1 kg/m<sup>2</sup> increase in BMI, the DBP increases by 0.420

mm Hg. Additionally, DBP for men is 2.244 mm Hg higher than that for women.

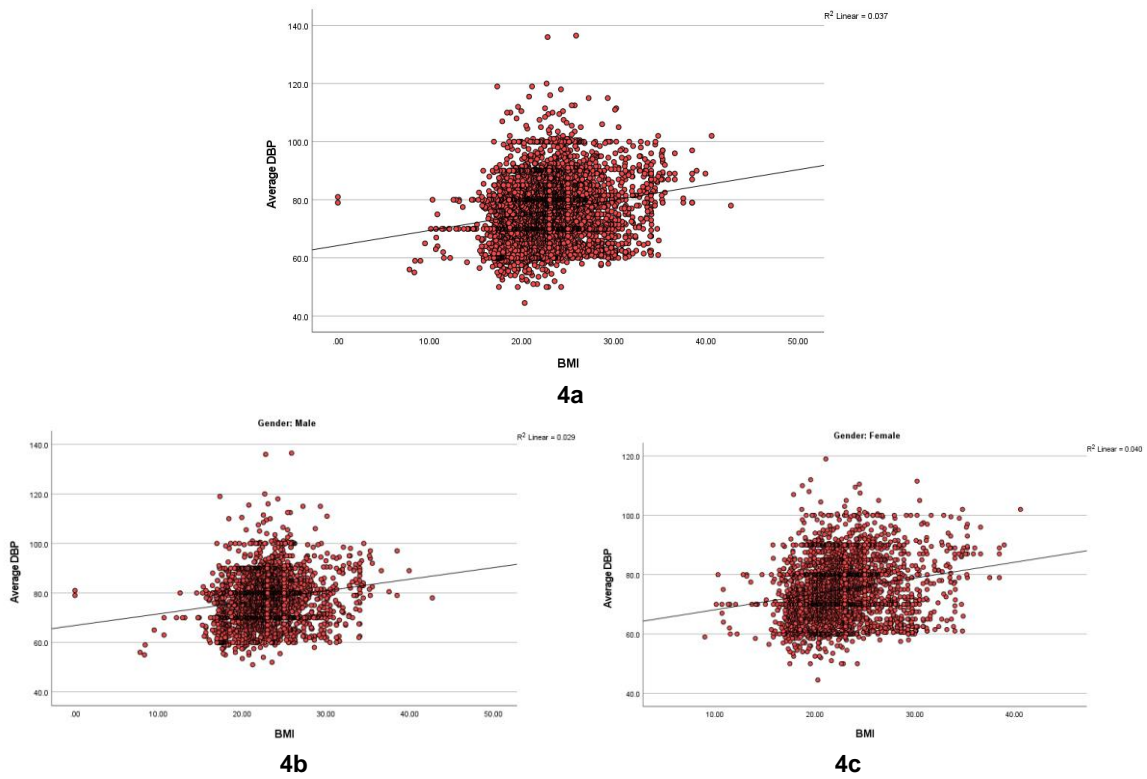
Table 5 demonstrates the comparison of hypertension risk across different BMI subgroups. The results show that the prevalence of hypertension incrementally increased with higher BMI values. In comparison with the normal weight BMI subgroup, the risk of hypertension was 1.81 times greater in the overweight BMI subgroup (OR, 1.81; 95% CI, 1.58 to 2.07; *P* < 0.05), and 1.91 times greater in the obese BMI subgroup (OR, 1.91; 95% CI, 1.67 to 2.18; *P* < 0.005). Conversely, the underweight BMI subgroup exhibited a reduced risk compared with the normal BMI subgroup (OR, 0.34; 95% CI, 0.27 to 0.43; *P* < 0.05).



**Figure 2:** The image demonstrates the mean systolic blood pressure (SBP) and the mean diastolic blood pressure (DBP) across various body mass index subgroups.



**Figure 3:** The images showcase the correlation between body mass index and systolic blood pressure indices (a) in both sexes: (b) in males and (c) in females.



**Figure 4:** The images demonstrate the correlation between body mass index and diastolic blood pressure indices (a) in both sexes: (b) in males and (c) in females.

**Table 3:** Results of Multivariable Linear Regression Model Between SBP and Prognostic Variables

SBP	Regression coefficient	Standard deviation	t value	P	95% CI
Constant	70.876	1.386	51.12	p<0.001	68.158 – 73.594
Age	0.402	0.013	29.81	p<0.001	0.375 – 0.428
BMI	1.414	0.056	25.06	p<0.001	1.303 – 1.524
Sex	3.240	0.414	7.82	p<0.001	2.427 – 4.952

SBP: systolic blood pressure, BMI: body mass index

**Table 4:** Results of Multivariable Linear Regression Model Between DBP and Prognostic Variables

DBP	Regression coefficient	Standard deviation	t value	P	95% CI
Constant	57.829	0.830	69.71	p<0.001	56.203 – 59.456
Age	0.149	0.008	18.52	p<0.001	0.134 – 0.165
BMI	0.420	0.034	12.44	p<0.001	0.354 – 0.486
Sex	2.244	0.248	0.05	p<0.001	1.758 – 2.730

DBP: diastolic blood pressure, BMI: body mass index

**Table 5:** Logistic Regression Analysis Between BMI Subgroups and Hypertension

Variables		OR	95% CI	P
BMI Subgroups	Underweight	0.34	0.27 – 0.43	<0.001
	Normal weight	1	Reference	
	Overweight	1.81	1.58 – 2.07	<0.001
	Obesity	1.91	1.67 – 2.18	<0.001

BMI: body mass index

## DISCUSSION

### 1. Clinical characteristics and BMI of hypertensive patients

Our study involving 5910 Vietnamese adults found an overweight and obesity rate of 20.8%. Comparing our results to previous studies, the overweight rate was lower than the 27.5% reported in 2005<sup>12</sup> and the 27.6% reported by Tran Thai Phuc.<sup>13</sup> On the other hand, the obesity rate was higher than the 5.7% reported in 2005<sup>12</sup> and significantly higher than the NCD Risk Factor Collaboration (NCD-RisC) 2014 estimate.<sup>14</sup> These comparisons suggest a notable decrease in overweight rates and a rapid increase in obesity rates compared with previous studies. Additionally, our findings indicate a significant decrease in underweight rates from 25.0% in 2000<sup>15</sup> and 20.9% in 2005.<sup>15</sup> The observed shift from a predominantly underweight

population to one increasingly facing an obesity epidemic is a concerning trend that demands greater attention.

A detailed discussion on the prevalence of hypertension will be provided upon announcing the results of the MMM Vietnam 2023 program. In the context of this study, a significant difference in hypertension prevalence among BMI subgroups was observed. Significantly, the hypertension rate in the overweight group was 43.9%, while the obesity group demonstrated a hypertension rate of 45.2%. The findings of our study clearly demonstrate an increased incidence of hypertension with higher BMI. Nonetheless, it is noteworthy that the hypertension rates across BMI subgroups in our study were considerably lower than those reported in a study by Landi et al.<sup>16</sup> In their study, hypertension rates were 67% in overweight individuals, 79% in individuals

with grades I and II obesity, and 87% in those with grade III obesity. The observed discrepancy in hypertension rates across BMI subgroups between our study and Landi et al's study may be attributed to several factors. These include variations in disease prevalence, ethnic differences, and unique dietary and exercise habits specific to the Vietnamese population.

## 2. Relationship between BMI and blood pressure

Our study further establishes the association between hypertension and various BMI subgroups. Through logistic regression analysis, we determined that individuals in the overweight and obese BMI subgroups were 1.81 and 1.91 times more likely to have hypertension, respectively, when compared with those with normal BMI. These findings align with previous studies, notably a follow-up study that identified overweight and obesity as risk factors for hypertension.<sup>6</sup> The relationship between obesity and hypertension is multifaceted and involves various complex mechanisms. Several proposed mechanisms underlying this association include overactivity of the sympathetic nervous system, activation of the renin-angiotensin-aldosterone system, alterations in adipose-derived cytokines, insulin resistance, and changes in kidney structure and function.<sup>7</sup> In our study, we observed a statistically significant positive correlation between BMI and SBP in both sexes ( $r = 0.339$ ,  $P < 0.05$ ), as well as in male ( $r = 0.324$ ,  $P < 0.05$ ) and female ( $r = 0.345$ ,  $P < 0.05$ ) participants, as depicted in Figures 3a, 3b, and 3c. Further, we found a statistically significant positive correlation between BMI and DBP, as demonstrated by the Pearson correlation coefficient value (Fig. 4). Our findings are consistent with previous studies conducted in this area.<sup>17,18</sup>

Our study offers a dependable assessment of the relationship between BMI and SBP

within the context of Vietnam, a developing country in Southeast Asia. Although age and sex are recognized factors influencing hypertension incidence, BMI remains a primary determinant when considering sex and adjusting for age.<sup>19</sup> A robust link exists between BMI and the emergence of hypertension; even slight weight gain during early life considerably increases the risk of hypertension. Moreover, obesity and overweight continue to heighten this risk, even when these conditions manifest later in life.<sup>6</sup>

Using multivariate regression that accounted for age, sex, and BMI, we obtained the following regression equations:

$$\text{SBP} = 70.876 + 0.402 (\text{age}) + 1.414 (\text{BMI}) + 3.240 (\text{sex})$$

$$\text{DBP} = 57.829 + 0.149 (\text{age}) + 0.420 (\text{BMI}) + 2.244 (\text{sex})$$

These equations indicate that for every 1 kg/m<sup>2</sup> increase in BMI, SBP rises by 1.414 mm Hg, and DBP increases by 0.420 mm Hg. In short, BMI is a straightforward and easily measured indicator.

Considering the findings of this study, we suggest utilizing BMI as a screening tool for both obesity and hypertension and advocating its widespread use in public health strategies. Moreover, regulating BMI, particularly weight, among individuals with hypertension emerges as a critical approach and should be strongly emphasized in Vietnam's healthcare initiatives.

It is essential to acknowledge some limitations of this study. Firstly, due to its nationwide scope and implementation in local healthcare facilities, we could not evaluate certain subclinical factors directly related to hypertension and obesity due to constraints within these medical establishments. Secondly, our database did not permit a comprehensive evaluation of blood pressure, overweight, and obesity risk factors. Thirdly, the association between

BMI and blood pressure in this study was based on a single point in time, being a cross-sectional analysis. To further enhance our understanding of this relationship, we plan to continue monitoring and analyzing data from future iterations of the Vietnam MMM programs.

## CONCLUSIONS

Our screening study of 5910 Vietnamese adults revealed that 2138 individuals had hypertension. The prevalence rates of hypertension in the overweight and obesity subgroups were 20.8%, while the underweight subgroup had a rate of 9.9%. A notable association was found between BMI subgroups and hypertension. Individuals with a BMI in the overweight or obese subgroups demonstrated a 1.81- and 1.91-times higher risk of hypertension, respectively, than those with normal BMI.

Our study revealed a positive correlation between BMI and blood pressure, with every 1 kg/m<sup>2</sup> increase in BMI resulting in a 1.414 mm Hg increase in SBP and a 0.402 mm Hg increase in DBP. These findings enrich our understanding of hypertension, overweight, and obesity in Vietnam. Consequently, we emphasize the significance of weight management in individuals irrespective of their hypertension status and advocate for using BMI as a community-level screening tool for hypertension.

## Conflict of Interest

The authors declare that they have no conflicts of interest concerning the content of this article.

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