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ORIGINAL ARTICLE

Prevalence of Undiagnosed Hypertension and Its Associated Factors Among the University Staff

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ABSTRACT

Introduction: Hypertension is a public health concern that is associated with heart disease. This study aims to investigate the prevalence of undiagnosed hypertension and its associated factors among the staff in a private university in Selangor, Malaysia. **Methods:** 100 respondents participated in this cross-sectional study. Blood pressure, Body Mass Index (BMI), percentage body fat (%BF), visceral fat rating (VFR), and waist circumference (WC) were measured. Questionnaires regarding knowledge, attitude, and practice (KAP) of salt diet validated from WHO/PAHO and Food Frequency Questionnaires regarding sodium intake validated from IPH Malaysia were administered. Statistical data was analysed using SPSS. **Results:** The prevalence of undiagnosed hypertension was 24%. About 66% of the participants had excessive sodium intake. The mean sodium intake was 2869.43±930.75mg/d. Simple linear regression showed that BMI. %BF, VFR, and WC were significantly correlated with systolic blood pressure (SBP). Age and sodium intake were not correlated with SBP. After controlling all the variables in multiple linear regression, VFR remained as a significant contributor to SBP (adjusted R2=0.419, F=18.833, p=<0.001). Soy sauce, omelette, fried rice, and nasi lemak were the main contributors of sodium intake. A lack of knowledge on the negative impacts of high salt diet was significantly associated with high dietary sodium intake (>2400mg/d). **Conclusion:** Our study found a high prevalence of undiagnosed hypertension among the private university staff. The association between VFR and SBP is an important finding for community study. Increased awareness on the excessive salt consumed and its association with health is needed to reduce the sodium intake.

Keywords: Undiagnosed hypertension, Visceral fat, Dietary sodium intake, Knowledge attitude and practice, High sodium food

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INTRODUCTION

Hypertension is a major public health crisis that affects 1 billion adults aged more than 25 years old, while two-third of the cases happens in developing countries (1). In the South East Asia region, the estimated number of adults diagnosed will increase to approximately 1.56 billion by 2025 (2). Hypertension is defined as a persistent elevation in Systolic Blood Pressure (SBP) ≥140mmHg and/or Diastolic Blood Pressure (DBP) ≥90mmHg (3). It is a chronic medical condition whereby the force exerted on the blood vessels is consistently too high when the heart pumps. In Malaysia, the overall prevalence of hypertension among the adults was 30.3%, 17.2% was undiagnosed, which was higher than the prevalence of known hypertension (13.1%), according to the National Health and Morbidity Survey (NHMS) 2015 (4).

The early detection of undiagnosed hypertension is crucial because untreated hypertension is associated with the burden of heart disease, stroke and kidney failure, which are the leading causes of premature disability and mortality (1). Buck et al. suggested that earlier onset and longer duration of hypertension leads to a greater risk of cardiovascular events in the future (5). Thus, investigating the factors associated with undiagnosed hypertension in Malaysia is essential for the public health sector to reduce the burden of this disease.

Being overweight or obese is accountable for many health complications especially diabetes mellitus, cancer, cardiovascular diseases, and hypertension (6). Indeed, overweight and obese are the major precursors of disability and death worldwide and its rate is projected to increase in the coming years. In Malaysia, the NHMS 2015 reported the prevalence of overweight and obesity among adults aged ≥18 years old to be 30% and 17.7% respectively. The pathogenesis of obesity-related hypertension can be explained by some important functions such as activation of the sympathetic nervous system, sodium retention which brings to an increase in renal absorption, the renin-angiotensin system, and the amount of intra-abdominal and intra-vascular fat (7). Moreover, the risk of metabolic syndromes is higher in individuals with central obesity. It was reported that individuals with high intra-abdominal fat had nearly three times higher odds of being hypertensive whereas individuals with high body fat had only two times higher odds of being hypertensive compared to those with normal body fat (8).

Previous study highlighted that a high salt diet is a leading factor for the development of hypertension and cardiovascular diseases (9). Reducing salt intake to ≤5g of salt per day (2000mg/d of sodium) which is a level recommended by World Health Organization (WHO) can prevent 1.65 million of deaths caused by cardiovascular complications each year (10). Whereas, Malaysian Dietary Guideline recommends that individuals should not eat more than 6g of salt per day (2400mg/d of sodium) (11). However, despite the health risks correlated with high salt intake, the population generally consumed salt which exceeds the recommendation. Worldwide mean sodium taken by adults in 2010 was 3.95 (95% CI 3.89-4.01) g per day (12), equivalent to 10.06 (9.88-10.21) g per day of salt. In Malaysia, the sodium intake among Malaysian adults which was assessed using 24-hour dietary recall, was 1935 mg per day, according to IPH (13). MySalt report conducted by IPH reported a sodium intake of 2860mg/d from 24-hour urine analysis and 3393mg/d from food frequency questionnaire among staff in the Ministry of Health Malaysia (14).

In Malaysia, salt can be obtained easily in the market as it functions as a food preservative, flavour and nutrient enhancer, and texture enhancer. Hence, it is available in the fish and meat products, dairy products, rice and noodles, confectionery, sauces, and pickles (15). The amount of salt in the seasonings and condiments added in the food is usually underestimated by the consumers. For example, one serving of Penang Laksa contributes to 1266mg of sodium (14), which is 63% of daily recommended value.

Salt intake was also thought to be influenced by an individual's knowledge, attitude and practice (KAP) of salt diet. Consumers are not always aware of the foods or dietary habits that contribute the most to the total sodium intake (14). If the awareness on salt intake is first taken into account, the development and implementation of national public health campaigns towards salt reduction can be successful.

To the best of our knowledge, no study has been reported on the prevalence of undiagnosed hypertension and its associated factors among the staff in the University of Nottingham Malaysia. Given the high prevalence of undiagnosed hypertension among Malaysian adults and the adverse consequence of high sodium intake on blood pressure, therefore, the aim of this study is to determine the prevalence of undiagnosed hypertension and its associated factors among the staff in the University of Nottingham Malaysia.

MATERIALS AND METHODS

Study design and respondents

A cross-sectional study was conducted among the staff in the University of Nottingham Malaysia located in Selangor, Malaysia from November 2018 to April 2019. Convenience sampling method was used in this study because of its easy accessibility for the researchers. Participants were recruited through the university email system, by distributing flyers or approached face-to-face by the researchers. They were informed about the study design and were required to sign a consent form before participating in this study. This study was approved by the Science and Engineering Research Ethics Committee (SEREC) from the University of Nottingham Malaysia (reference number TCM191018).

The sample size determination was based on the prevalence of hypertension among Malaysian adults (30.3%) according to the NHMS 2015 (4), with 95% confidence interval, 10% margin of error, and an additional 20% of non-response rate. Based on the calculation, a total of 97 participants was needed. The inclusion criteria were male and female aged between 21 and 65 years old with no self-reported medical history of hypertension and did not have their blood pressure measured in the past 6 months. Pregnant women and those who were taking any anti-hypertensive drugs were excluded from the study to avoid any confounding factors due to the pregnancy and the effect of drugs.

Data Collection

Body height (m) was obtained using SECA 217 stadiometer. Body weight (kg), percentage body fat (%), and visceral fat rating were obtained using the Omron HBF-516B body composition monitor. For body weight, the measurement was taken to the nearest 0.1kg with the subjects wearing light clothing. Body Mass Index (BMI) was calculated using the formula [Weight (kg)]/[Height (m) x Height (m)]. It was then classified into four categories: Underweight (below 18.5kg/m^2), normal weight (18.5-24.9kg/m^2), overweight (25-29.9kg/m^2), and obesity (above 409kg/m^2) (16).

Waist circumference (cm) which represents the truncal distribution of adipose tissue was used in this study because this measurement is strongly correlated with the adverse metabolic and vascular effects of obesity compared to subcutaneous fat (17). It was measured using a non-elastic measuring tape to the nearest 0.1cm. The reading was taken in a horizontal plane at the midpoint between the lower border of the ribs and the iliac crest (18). Measurement was made with the participant's arms relaxed during the end of normal expiration. Waist Hip Ratio (WHR) is another measurement used in epidemiological studies but it does not provide additional information compared to WC (17). Thus, in this study, waist circumference is the preferred measure of abdominal obesity compared to the WHR.

Systolic and diastolic blood pressure (mmHg) were measured using the Omron HEM-7120 Automatic Blood Pressure Monitor after the subjects had rested for at least five minutes. Two readings were taken on the subject's right arm and the average was recorded. Individuals with undiagnosed hypertension had a measurement that indicated hypertension, which was defined at systolic blood pressure ≥140mmHg, diastolic blood pressure ≥90mmHg, or both (3), but had not been informed by a doctor that they had hypertension.

A self-administered questionnaire was then given to the subjects, which consisted of three parts:
Part A: Socio-demographic background. The data included gender, age, ethnicity, marital status, highest education level, household monthly income level, physical activity level, and smoking status. Physical activity level was self-reported and was categorized into five levels: Extra active (training twice daily), very active (six days/week – hard), moderate (three days/week – hard or five days/week – light), light (walking, etc one to three days/week), and none (little or no regular exercise). Smoking status was categorized according to subjects' response to the following items: "Have you ever smoked cigarettes, cigars, shisha, pipes, etc?" and "Do you currently smoke?" Subjects who responded "Yes" to both questions were categorised as "current smokers" whilst those who responded "Yes" to the first question and "No" to the second question were categorised as "Ex-smokers". Respondents who responded "No" to both questions were categorised as "Never smoked". In our analysis, ex-smokers and never-smokers were combined and constituted the non-smokers' category (19).

Part B: Knowledge, Attitude, and Practice (KAP) of salt intake. Level of KAP of salt intake was accessed using a validated questionnaire adapted from WHO/Pan American Health Organization (20). To assess the level of knowledge, the subjects were asked if they think that a high salt diet could cause a serious health problem, including hypertension. To assess subjects' attitude on salt intake, they were asked the amount of salt they thought they consume and the level of importance to them in lowering the salt/sodium in their diet. To assess their practice on salt intake, they were asked the frequency of adding salt in the cooking at home, and if they take any initiative to control salt/sodium intake, from a range of options including avoiding/minimizing processed foods, looking at the salt labels, not adding salt at the table, buying low salt alternatives, not adding salt when cooking, and using spices other than salt when cooking.

Part C: Food Frequency Questionnaire (FFQ). The FFQ contained 102 common food items high in sodium which were categorized into 11 food groups. It was validated from the previous study by IPH (14). The food groups included meat/poultry products, fish/seafood products, eggs, spreads, "kuih muih" or desserts, snacks, sauces/seasonings, fast foods, cooked foods (grain products), cooked foods (others), and canned foods. Subjects were required to fill in the number of food servings taken in day/week/month for the previous one month. Then, the estimated sodium intake of the subject was calculated using the formula [sodium content per serving (g) * number of serving taken on per day basis]. This FFQ would reflect the subjects' sodium intake per day for the past one month.

Data analysis
Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 24.0 software. Data normality test was performed. Descriptive data were used to summarise categorical variables and the data was presented as number and percentage. For continuous variables, the data were presented as mean ± standard deviation (SD). Chi-square test was used to examine associations between two categorical variables. Independent t-test was used to compare the differences of continuous variables by hypertensive status. Simple linear regression was used to study the variables associated with SBP. The variables that produced $p<0.05$ in the simple linear regression model were chosen to be included in the multiple linear regression analysis. A p-value of <0.05 was considered significant.

RESULTS

Sociodemographic characteristics
A total of 100 participants participated in this study (54 females and 46 males). Table I shows the socio-demographic characteristics of the subjects by hypertensive status. The mean age was 34.56 ± 9.08 years old. There were no significant differences in socio-demographic characteristics between undiagnosed hypertensive and non-hypertensive groups.

Anthropometric characteristics and blood pressure
Table I shows the anthropometric characteristics and blood pressure by hypertensive status. 24% of the subjects were found to have undiagnosed hypertension. Undiagnosed hypertensive subjects had significantly greater body weight, BMI, percentage body fat, visceral fat rating, and waist circumference compared to non-hypertensive subjects.

Body mass index category and hypertensive status
Table II shows a significant association between body mass index category and hypertensive status among the subjects. Based on the BMI classification by WHO (16), 65% of the subjects had a weight problem (7% underweight, 30% overweight, and 28% obese) with an overall mean BMI of 26.04 ± 5.7 kg/m^2. In

Table I: Socio-demographic, anthropometric characteristics and blood pressure of the subjects by hypertensive status

Variable	Total n=100 n (%)	Hypertensive n= 24 n (%)	Non-hypertensive n=76 n (%)	p value
Age (years)				
(mean ± SD)	34.56 ± 9.08	34.83 ± 10.42	34.47 ± 8.68	0.867
Gender				
Male	46 (46)	15 (62.5)	31 (40.8)	0.099
Female	54 (54)	9 (37.5)	45 (59.2)	
Age group (years)				
21-30 years	41 (41)	10 (41.7)	31 (40.8)	0.116
31-40 years	30 (30)	5 (20.8)	25 (32.9)	
41-50 years	22 (22)	8 (33.3)	14 (18.4)	
51-60 years	6 (6)	0	6 (7.9)	
61-70 years	1 (1)	1 (4.2)	0	
Ethnicity				
Malay	45 (45)	11 (45.8)	34 (44.7)	0.471
Chinese	26 (26)	8 (33.3)	18 (23.7)	
Indian	22 (22)	5 (20.8)	17 (22.4)	
Others	7 (7)	0	7 (9.2)	
Marital status				
Single	36 (36)	11 (45.8)	25 (32.9)	0.492
Married	63 (63)	13 (54.2)	50 (65.8)	
Widowed	1 (1)	0	1 (1.3)	
Highest education level				
Secondary	4 (4)	1 (4.2)	3 (3.9)	1.000
Tertiary	96 (96)	23 (95.8)	73 (96.1)	
Household income level				
Less than RM3000	27 (27)	9 (37.5)	18 (23.7)	0.106
RM3001-RM6000	40 (40)	11 (45.8)	29 (38.2)	
RM6000 or above	33 (33)	4 (16.7)	29 (38.2)	
Smoking status				
Yes	9 (9)	4 (16.7)	5 (6.6)	0.212
No	91 (91)	20 (83.3)	71 (93.4)	
Physical activity level				
Extra active	3 (3)	2 (8.3)	1 (1.3)	0.124
Very active	6 (6)	0	6 (7.9)	
Moderate	24 (24)	3 (12.5)	21 (27.6)	
Light	53 (53)	15 (62.5)	38 (50.0)	
None	14 (14)	4 (16.7)	10 (13.2)	
[a]Anthropometric				
Height (m)	1.65 ± 0.09	1.67 ± 0.09	1.64 ± 0.09	0.125
Weight (kg)	71.10 ± 19.03	85.81 ± 19.57	66.45 ± 16.42	<0.001***
Body mass index (kg/m^2)	26.04 ± 5.73	30.50 ± 5.62	24.63 ± 5.03	<0.001***
Percentage body fat (%)	33.21 ± 10.01	37.23 ± 9.38	31.95 ± 9.93	0.024*
Visceral fat rating	7.69 ± 4.39	11.04 ± 4.49	6.63 ± 3.82	<0.001***
Waist circumference (cm)	86.78 ± 19.14	101.29 ± 12.98	82.20 ± 18.52	<0.001***
[a]Blood pressure (mmHg)				
Systolic	122.50 ± 15.39	140.90 ± 7.21	116.69 ± 12.42	<0.001***
Diastolic	80.93 ± 10.54	93.33 ± 7.81	77.01 ± 7.95	<0.001***

Chi-square test was performed with no significant difference.
[a]Independent t-test was performed with significant differences at *p<0.05, ***p<0.001.

Table II: Association between BMI category and hypertensive status in subjects

BMI category	Hypertensive n = 24 n (%)	Non-hypertensive n = 76 n (%)	p value
Underweight	0	7 (9.2)	0.002*
Normal weight	3 (12.5)	32 (42.1)	
Overweight	8 (33.3)	22 (28.9)	
Obese	13 (54.2)	15 (19.7)	

*Chi-square test was performed with significant difference at p<0.05.

terms of hypertensive status, most of the undiagnosed hypertensive subjects were either overweight (33.3%) or obese (54.2%). In contrast, most of the non-hypertensive subjects had normal weight (42.1%).

Dietary sodium intake

Overall, the mean sodium intake estimated by FFQ was 2869.43 ± 930.75mg/d, ranged in between 999.97mg/d and 5123.39mg/d (Table III). No significant difference was found in the sodium intake between undiagnosed hypertensive and non-hypertensive subjects. According to the estimates, 20% of the subjects met the WHO's recommendation of <5g/d of salt (2000mg/d of sodium). 34% of the subjects met the national recommendation of <6g/d of salt (equivalent to 2400mg of sodium).

Table III: Dietary sodium intake in the subjects

Characteristics	Dietary sodium intake n=100	p value
Overall (mg/d)		
Mean ± SD	2869.43 ± 930.75	
Median	2890.40	
25th, 75th percentile	2100.06, 3564.52	
Gender		
Male	2499.95 ± 816.86	<0.001***
Female	3184.17 ± 912.26	
Hypertensive status		
Hypertensive	2785.67 ± 949.62	0.616
Non-hypertensive	2895.88 ± 929.52	
n (%)		
WHO recommendation <2000mg/d		
Met the recommendation	20 (20.0)	
National recommendation <2400mg/d		
Met the recommendation	34 (34.0)	

Independent t-test was performed with significant difference at ***p<0.001.

Factors associated with blood pressure

Simple linear regression and multiple linear regression were conducted to study the continuous variables associated with systolic blood pressure (SBP) and the results were demonstrated in Table IV. The relationship with diastolic blood pressure (DBP) was not reported as

Table VII: Association between dietary sodium and Knowledge, attitude, and practice of salt diet

Variables	Dietary sodium estimated by FFQ Total n=100 n (%)	Normal n=34 n (%)	High n=66 n (%)	χ^2	p value
Knowledge					
High salt diet can cause serious health problem.					
Yes	84 (84)	32 (94.1)	52 (78.8)	8.751	0.003**
No	3 (3)	2 (5.9)	1 (1.5)		
Unsure	13 (13)	0	13 (19.7)		
High salt diet can cause hypertension.					
Yes	82 (82)	32 (94.1)	50 (75.8)	7.700	0.010*
No	5 (5)	2 (5.9)	3 (4.5)		
Unsure	13 (13)	0	13 (19.7)		
Attitude					
How important to you is lowering salt in your diet?					
Very important	44 (44)	18 (52.9)	26 (39.4)	2.330	0.354
Important	45 (45)	14 (41.2)	31 (47.0)		
Not important	11 (11)	2 (5.9)	9 (13.6)		
How much salt do you think you consume?					
Too much	8 (8)	1 (2.9)	7 (10.6)	2.483	0.522
Right amount	76 (76)	27 (79.4)	49 (74.2)		
Little	6 (6)	3 (8.8)	3 (4.5)		
Unsure	10 (10)	3 (8.8)	7 (10.6)		
Practice					
In the food eaten at home, salt is added in cooking.					
Always/Often	78 (78)	25 (73.5)	53 (80.3)	0.617	0.686
Sometimes	15 (15)	6 (17.6)	9 (13.6)		
Rarely/Never	7 (7)	3 (8.8)	4 (6.1)		
Take regular action to control salt intake.					
Yes	50 (50)	16 (47.1)	34 (51.5)	0.586	0.746
No	36 (36)	12 (35.3)	24 (36.4)		
Unsure	14 (14)	6 (17.6)	8 (12.1)		
1) Avoid/minimize processed foods.					
Yes	39 (39)	15 (44.1)	24 (36.4)	0.567	0.451
No	61 (61)	19 (55.9)	42 (63.6)		
2) Read the salt labels.					
Yes	12 (12)	2 (5.9)	10 (15.2)	1.826	0.213
No	88 (88)	32 (94.1)	56 (84.8)		
3) Do not add salt on the table.					
Yes	22 (22)	7 (20.6)	15 (22.7)	0.060	0.807
No	78 (78)	27 (79.4)	51 (77.3)		
4) Buy low salt alternatives.					
Yes	14 (14)	3 (8.8)	11 (16.7)	1.147	0.371
No	86 (86)	31 (91.2)	55 (83.3)		
5) Do not add salt when cooking.					
Yes	3 (3)	1 (2.9)	2 (3.0)	0.001	1.000
No	97 (97)	33 (97.1)	64 (97.0)		
6) Use spices other than salt when cooking.					
Yes	16 (16)	7 (20.6)	9 (13.6)	0.807	0.369
No	84 (84)	27 (79.4)	57 (86.4)		

Chi-square test was performed with significant differences at *p<0.05, **p<0.01.

it did not contribute to more information and SBP is the more decisive parameter associated with hypertension (21). Significance was found in the simple linear regression for BMI, %BF, VFR, and WC. For age and dietary sodium intake, no significant difference was found. This suggests that in the studied subjects, age and dietary sodium were not associated with SBP. The results from multiple linear regression analysis indicated R= 0.665, adjusted R^2= 0.419, F= 18.833, p<0.001. The current study found that visceral fat rating (β= 0.325, p= 0.043) remained as a significant predictor of SBP after other variables were adjusted.

Main sources of sodium in the diet

Intake of high sodium foods for the past one month by the subjects was assessed and calculated according to their daily, weekly, or monthly consumption. Table V indicates the top 20 food sources with the highest sodium consumption by the subjects. The highest sodium consumption per day was contributed by light soy sauce (Kicap cair) with a mean consumption of 200.46mg/d, followed by omelette (194.62mg/d), fried rice (187.34mg/d), nasi lemak (168.10mg/d) and fried chicken with spice (137.68mg/d).

Table VI demonstrates the intake pattern of the top 20 high sodium foods by the subjects. The food items were ranked based on their sodium content per 100g of the weight. Light soy sauce (Kicap cair) contains the highest sodium per 100g, and it was a popularly consumed food item in the diet (n=56). Whereas, anchovies' sauce (sos ikan bilis) has the second-highest sodium content but was not regularly consumed by the subjects (n=4). Therefore, it contributes to low sodium intake (14.35mg/d). Soy sauce, other sauces (oyster, tomato, and chilli), vegetables in soy/oyster sauce, cheese, and sambal belacan were some of the high sodium foods consumed commonly by the subjects.

Table V: Top 20 food sources with the highest sodium consumption

No.	Food item	N	Number of participants	Mean sodium (mg/d)
1	Light soy sauce (Kicap cair)	100	56	200.46
2	Omelette (Telur dadar)	100	89	194.62
3	Fried rice (Nasi goreng)	100	72	187.34
4	Nasi lemak	100	53	168.10
5	Fried chicken with spice (Ayam goreng berempah)	100	76	137.68
6	Vegetables in soy/oyster sauce (Sayur goreng kicap/sos tiram)	100	41	117.66
7	Chicken rice (Nasi ayam)	100	57	117.29
8	Instant noodles (Mee segera)	100	49	105.71
9	Fried noodles (Mee goreng)	100	45	98.16
10	Soy sauce chicken (Ayam kicap)	100	38	77.68
11	Fish/shrimp/squid/crab ball/cake (Bebola atau kek ikan/udang/sotong/ketam)	100	50	72.53
12	Indian flatbread (Roti canai)	100	43	68.47
13	Stir fried vegetables (Sayur goreng)	100	63	67.59
14	Oyster sauce (Sos tiram)	100	36	58.99
15	Curry noodles (Mee kari)	100	21	57.47
16	Rendang chicken (Ayam rendang)	100	22	54.61
17	Noodles in soup (Mee sup)	100	22	54.45
18	Tomato/chilli sauce (Sos tomato/cili)	100	49	54.44
19	Mushroom/chicken creamy soup (Sup berkrim cendawan/ayam)	100	21	45.61
20	Spicy fried chicken (Ayam goreng spicy)	100	42	41.08

Table VI: Intake pattern of top 20 foods with the highest sodium content

No.	Food item	N	Number of participants	Mean sodium (mg/d)	Sodium (mg/g)
1	Light soy sauce (Kicap cair)	100	56	200.46	72.982
2	Anchovies sauce (Sos ikan bilis)	100	4	14.35	63.290
3	Budu	100	4	4.05	63.282
4	Cincaluk	100	0	0	44.886
5	Oyster sauce (Sos tiram)	100	36	58.99	39.154
6	Dark soy sauce (Kicap pekat)	100	32	31.26	28.078
7	Dried shrimp (Udang kering)	100	4	0.68	25.538
8	Sambal belacan	100	24	29.11	18.950
9	Salted fish (Ikan masin)	100	5	1.01	17.284
10	Gailan with salted fish (Sayur kailan ikan masin)	100	11	6.06	17.204
11	Cheese (Keju)	100	30	18.62	14.533
12	Vegetables in soy/oyster sauce (Sayur goreng kicap/sos tiram)	100	41	117.66	12.910
13	Cheesy wedges (Wedges berkeju)	100	11	10.33	11.920
14	Fried instant noodles (Mee segera goreng)	100	22	40.97	10.972
15	Tomato/Chilli sauce (Sos tomato/cili)	100	49	54.44	10.530
16	Sambal egg (Telur masak sambal)	100	11	10.76	10.389
17	Dried squid (Sotong kering)	100	5	1.60	10.371
18	Chicken/Pork ham/luncheon meat	100	22	20.35	9.830
19	Colonel/Fillet/Zinger/McChicken/Double cheeseburger	100	18	24.25	9.705
20	Pickled fruit (Jeruk buah-buahan)	100	6	4.70	8.395

Association between dietary sodium and Knowledge, attitude, and practice (KAP) of salt diet

Sodium intake of >2400mg/d was categorized as high dietary sodium. From Table VII, subjects who consumed high dietary sodium did not know about the harmful effects of the high salt diet which can cause serious health problem including hypertension. 19.7% of the respondents with high sodium intake answered "Unsure" for the statement "High salt diet can cause hypertension." compared to none of the subjects with

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Right amount	76 (76)	27 (79.4)	49 (74.2)		
Little	6 (6)	3 (8.8)	3 (4.5)		
Unsure	10 (10)	3 (8.8)	7 (10.6)		
Practice					
In the food eaten at home, salt is added in cooking.					
Always/Often	78 (78)	25 (73.5)	53 (80.3)	0.617	0.686
Sometimes	15 (15)	6 (17.6)	9 (13.6)		
Rarely/Never	7 (7)	3 (8.8)	4 (6.1)		
Take regular action to control salt intake.					
Yes	50 (50)	16 (47.1)	34 (51.5)	0.586	0.746
No	36 (36)	12 (35.3)	24 (36.4)		
Unsure	14 (14)	6 (17.6)	8 (12.1)		
1) Avoid/minimize processed foods.					
Yes	39 (39)	15 (44.1)	24 (36.4)	0.567	0.451
No	61 (61)	19 (55.9)	42 (63.6)		
2) Read the salt labels.					
Yes	12 (12)	2 (5.9)	10 (15.2)	1.826	0.213
No	88 (88)	32 (94.1)	56 (84.8)		
3) Do not add salt on the table.					
Yes	22 (22)	7 (20.6)	15 (22.7)	0.060	0.807
No	78 (78)	27 (79.4)	51 (77.3)		
4) Buy low salt alternatives.					
Yes	14 (14)	3 (8.8)	11 (16.7)	1.147	0.371
No	86 (86)	31 (91.2)	55 (83.3)		
5) Do not add salt when cooking.					
Yes	3 (3)	1 (2.9)	2 (3.0)	0.001	1.000
No	97 (97)	33 (97.1)	64 (97.0)		
6) Use spices other than salt when cooking.					
Yes	16 (16)	7 (20.6)	9 (13.6)	0.807	0.369
No	84 (84)	27 (79.4)	57 (86.4)		

Chi-square test was performed with significant differences at *p<0.05, **p<0.01.

normal sodium intake.

No significant differences were found in terms of attitude and practice of salt diet between both normal and high sodium intake groups. This signifies that this population's attitude and practice of salt diet are not the determinants of their sodium intake. 89% of the subjects considered it important to lower salt intake in their diet and 76% believed that they were consuming just the right amount of salt on a daily basis. Majority of them (97%) added salt during cooking and 78% of them added salt to meals at the table. Half of the subjects (50%) reported taking regular actions to control salt intake. Subsequent observation showed that 39% of the subjects avoided processed foods, 14% bought low salt alternatives, and 16% used spices other than salt when cooking. Only 12% of the participants read the salt labels before purchasing the food.

DISCUSSION

Association between anthropometric measurements and blood pressure

The prevalence of undiagnosed hypertension among studied subjects was 24% and this finding is comparable with a study among Western Indian by Shukla et al. (22). The prevalence is much higher compared to the NHMS study 2015 which found a prevalence of 17.2% among Malaysians. The difference is expected since the sample size and age range were different between the two studies. This magnitude of undiagnosed hypertension signifies a need for further attention as hypertension is strongly interlinked with other health complications.

Our study exhibited that most of the hypertensive subjects were either overweight or obese, with the percentage almost double of that in the non-hypertensive subjects. This is in line with the secondary data analysis from NHMS 2015 which reported that BMI is one of the factors associated with the severity of hypertension among Malaysian adults (23). An overweight person had three times higher odds of developing stage 2 hypertension as compared to those with normal BMI. Similarly, an obese individual had almost 14 times increased odds of getting Stage 2 hypertension as compared to those with normal BMI (23).

Furthermore, our findings suggested that visceral fat might be an important link between being overweight or obese and hypertension. Visceral adiposity, instead of total adiposity, plays a more important role in SBP elevation. Our result is supported by Petribъ et al. who found that visceral adiposity was statistically correlated with SBP among young women from Pernambuco (24). A cross-sectional study among Japanese men by Koh et al. found that the risk of developing high blood pressure is associated with visceral adiposity rather than subcutaneous adiposity (25). In the study, computed tomography (CT), a more accurate, expensive, and sophisticated method was used to determine the intra-abdominal fat area. Rattarasarn et al. added that visceral abdominal fat is correlated with SBP and DBP, hence it can act as a strong determinant for the cardiovascular risk factor (26).

The relationship observed in this study may be explained by two possible mechanisms. Firstly, adipocyte-derived circulating factors, for instance, plasminogen-activator inhibitor type 1, tumour necrosis factor α, or adiponectin, are responsible for blood pressure elevation (27). Visceral fat was found to play a more significant role in generating the mentioned circulating factors rather than subcutaneous fat. Besides, the pathophysiological relationship may be partly related to the change in insulin sensitivity and its compensatory hyperinsulinemia. Free fatty acid generated from visceral fat promotes insulin resistance in skeletal muscle and liver (28). Hyperinsulinemia may cause an increase in sympathetic activity and sodium tubular absorption, which may, in turn, cause hypertension. Hence, visceral fat, rather than BMI and subcutaneous fat was associated with the development of hypertension.

Association between dietary sodium intake and blood pressure

The mean sodium intake in our study, 2869.43 ± 930.75mg/d, exceeded the recommendation of 2400mg/d by the Ministry of Health Malaysia by 19.6% (11). Up to 66% of the subjects exceeded the recommended sodium intake of 2400mg/d. Thus, sodium intake among the studied population is relatively high. However, the data on sodium intake differs in Malaysia setting. The current sodium intake is lower compared to the MySalt report by IPH which estimated sodium intake using the same FFQ (3393 ± 2580mg/d) (14). The reason could be due to the over-reporting in the aforementioned study as the researchers found that the overall mean sodium analysed by this method was higher than the 24-hour urine analysis. In comparison with studies from other countries whereby FFQ was used, the mean sodium intake in the current study was lower (29-31).

Excessive dietary sodium intake has long been linked with elevated blood pressure (9). However, the current study found no correlation between sodium intake and blood pressure. This finding is in contrary to the previous studies, which found an increased risk of elevated BP with high dietary sodium. For instance, the SALTURK study reported that for every 800mg of increased sodium intake, there will be an increase in SBP by 5.8mmHg (32). The difference could be due to different mean sodium between SALTURK study (7200mg/d) and the current study (2869.43mg/d). However, our finding is supported by a large-scale, 16-years Framingham Offspring Study which reported that dietary sodium estimated by the 6-day dietary record was not positively correlated with both SBP and DBP (33). Sharma et al. added that no relationship was found between dietary sodium estimated by 24-hour dietary recall and BP in the cross-sectional study in US adults with no history of hypertension (34). Kok et al. found no association between sodium intake estimated by a 1-week dietary recall and BP in the Netherlands (35).

We summed up several reasons for our findings. This could be due to the relatively fewer subjects with high blood pressure in this study, hence it was under-powered to reflect the relationship. Besides, several intervention studies agreed that lowering sodium intake can lower blood pressure in both normotensive and hypertensive adults (36). Perhaps our study examining sodium intake at the population level might explain the reason why the relationship was not found. Furthermore, the relationship between the two is not straightforward because hypertension is multifactorial. Blood pressure elevation following salt intake differs among individuals due to heterogeneous responses of sodium loading to blood pressure (37). Ducher et al. examining normotensive adults followed for two years found no association between sodium intake and BP at the population level but they found a correlation after conducting an analysis within individuals (38). They concluded that certain individuals have "salt-dependent blood pressure" which might benefit from salt intake reduction.

The validated FFQ from MySalt report was used in this study as the researchers found a significant, small, positive correlation with 24-hour urinary sodium ($r=0.131$, $p<0.01$) among the staff in the Ministry of Health Malaysia. Studies by Ferreira-Sae et al. and Park et al. also found some validity and reliability shown by using FFQ (39, 40). According to IPH, the FFQ is one of the most commonly used tools in huge population-based studies due to its nature of being administered easily and low in cost (14). It potentially reduces day-to-day sodium intake variability and is more likely to represent a subject's habitual intake pattern. Moreover, the main food sources with the highest sodium consumption can be identified. However, contradictions emerged in several other studies reporting poor agreement between predictions from FFQ and 24-hour urinary sodium due to misreporting (41, 42). Although 24-hour urine collection is the gold standard for evaluation, it is complex and expensive due to the subject's burden. Considering the strengths and weaknesses of FFQ, it was in the meantime the most suitable method to assess sodium intake in this study. Hence, the poor relationship between dietary sodium and SBP might also be explained by the misreporting or the suboptimal use of the FFQ.

Our result indicated that soy sauce, omelette, fried rice, and nasi lemak were the major sources of sodium consumption. MySalt report also found that these food items contributed to major sodium consumption by the participants. Nevertheless, subjects in our study rarely consumed some foods such as anchovies' sauce, budu, dried shrimp, and salted fish which were among the highest sodium content per 100g. Most sodium in Asian countries is obtained from added sodium chloride in cooking and different sauces, such as soy sauce and miso (14). A study among Singaporeans, who share a similar dietary pattern with Malaysians, revealed that 60% of the dietary sodium in their local diet came from table salt and sauces (43). On the other hand, in European and United States diets, sodium is mainly from processed foods (44).

Association between dietary sodium intake and Knowledge, Attitude, and Practice of salt diet

This study highlighted that insufficient knowledge on the negative impacts of a high salt diet can result in excessive dietary sodium intake. Our study also found that subjects with high dietary sodium intake had poor knowledge about the links between salt and hypertension. Mahat et al. also found a similar trend among the Malay healthcare staff in Malaysia (45). There is a tendency to consume sodium excessively in the diet if the population are not aware of the consequences. Our finding also reported that majority of the subjects on a high sodium diet did not consider their salt intake as a problem. This is justifiable, since people with hypertension are largely asymptomatic and most of the subjects perceived their salt intake as the right amount, therefore there is no need for them to reduce their current salt intake.

Nutrition information on the food labels is regarded as a major means for encouraging consumers to make healthier choices when purchasing the food. However, current finding revealed that only 12% of the respondents read the salt table content upon food purchasing. This finding corroborates the previous study which reported that majority of Malay healthcare staff in Malaysia with a high 24-hour urinary sodium excretion did not read the food label for salt before purchasing the food (45). Reading food labels for salt content is essential for an individual to control the sodium intake. Hence, awareness on the importance of reading food and salts labels to guide the purchasing decisions should be implemented at the university level.

It should be noted that most subjects in our study never take regular action to minimize processed foods. This may be due to the populations not being aware that processed foods are among the top foods with the highest sodium content (14). Hence, policies for dietary sodium reduction should focus on both raising the awareness on the sodium content of generally consumed foods in the public as well as reducing the salt content of the processed foods by the food industries.

Majority of the respondents in the current study reported that they tend to add salt both during cooking and on the table. This finding is in line with another study among the Greek adults where most people tend to add more salt in the food to enhance the sensory attributes of the foods (46). On the other hand, only a small proportion of subjects reported using spices other than salt when cooking. This is probably due to the lack of knowledge on the various alternative ways to add flavours to food such as spices and natural flavours such as lemon juice besides salt (45). Hence, subjects should be advised to practise using spices when cooking which is proven effective in reducing sodium intake (47).

Moreover, looking at the whole, we can conclude that the studied subjects identified that excessive salt intake is detrimental to health and half of the population took regular action to control salt intake, however, majority of them were still taking salt above the national recommendation. This scenario could be explained by the barriers to alter population's behaviour, for instance, the heavy advertisement of high-sodium low-cost food (48) in Malaysia and the inadequate labelling of sodium level, particularly in local food products because it is not mandatory (49). These, in turn, are the main limiting factors for salt reduction even among the well-informed population.

Our findings provide evidence that will enable the development of effective public health education intervention. Such intervention may aim to educate the public on the relationship between sodium and hypertension, to increase the public awareness on the salt recommendations for adults, sources of sodium in the diet, to encourage the reading of food labels and to promote alternative flavouring other than salt when cooking.

Study Limitations

Our study has several limitations. Firstly, due to its nature as a cross-sectional study, it is impossible to make strong statements about causality mechanism between visceral fat and blood pressure level. Secondly, visceral fat was not measured using the clinical diagnostic method (CT scan, MRI, or ultrasonography). The measurement using bioelectrical impedance could be affected by body water level (50). Besides, our study did not consider the diurnal effect of blood pressure due to time constraint. Forth is the difficulty in generating valid sodium intake information through a food frequency questionnaire as it entirely depends on the respondent's honesty and memory in reporting their intake. Other than that, our study did not consider other possible factors that may influence blood pressure level such as stress level, alcohol intake, family history, and other medical complications. After all, potentially unknown or unmeasured confounding factors are hard to be excluded for any observational study.

CONCLUSION

In conclusion, the prevalence of undiagnosed hypertension among university staff in the private university in Selangor, Malaysia was an alarming finding which requires attention. The current study emphasizes that VFR was associated with SBP elevation. It reflects central obesity; hence this parameter should not be overlooked by researchers in the community study. Besides, the mean sodium intake was greater than the recommendations both by the Ministry of Health Malaysia and WHO. Lack of knowledge on salt diet contributes to high sodium intake among the population. Sauces and cooked food were the major contributors of sodium. As hypertension is a major risk for cardiovascular diseases, earlier screening, diagnosis, and control should be in place within the university setting to combat this health issue. Interventions are needed in the university to improve population awareness of hypertension through campaigns and education. Further investigations should focus on determining whether reducing visceral adiposity and dietary sodium will improve blood pressure levels among the staff in the private university.

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