

# Prevalence and risk factors of prehypertension in university students in Sabah, Borneo Island of East Malaysia

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## Abstract

Unhealthy lifestyle contributes mainly to an increased prevalence of non-communicable diseases including hypertension and cardiovascular diseases tend to increase in Malaysia. These diseases lead to an increased risk of end organ damage and cardiovascular complications. In this study, the prevalence of prehypertension and its associated risk factors among a cohort of university students in Sabah was determined.

This is a prospective, cross-sectional study conducted among 365 undergraduate students irrespective of faculties at Universiti Malaysia Sabah (UMS). Standardized and validated World Health Organization (WHO) STEPS questionnaires were used to collect sociodemographic data. Additionally, clinical and anthropometric data were measured and recorded by a trained staff, followed by descriptive and logistic regression analyses.

A total of 365 UMS undergraduate students aged 18 years and above participated in the study. The prevalence of prehypertension among university students was high (31%) (95% CI [29.1%, 34.3%]). Well-known risk factors for hypertension including family history of hypertension, reduced sleep duration, reduced physical activity, smoking, being overweight or obese were significantly associated with the risk of developing prehypertension ( $P < .05$ ) among UMS students. However, no association was observed between ethnicity, age, and gender with prehypertension.

A worryingly high percentage of UMS students are prehypertensive, indicating the need of early preventive strategies aimed at increasing awareness, early screening, and lifestyle modification to reduce the rising burden of the disease and the associated complications in this age group.

**Abbreviations:** BMI = Body mass index, BP = blood pressure, CPG = Clinical Practice Guideline, NHMS = National Health and Morbidity Survey, UMS = Universiti Malaysia Sabah.

**Keywords:** associated risk factors, malaysian students, prehypertension, prevalence, undergraduate

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The datasets generated during and/or analyzed during the current study are not publicly available, but are available from the corresponding author on reasonable request.

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## 1. Introduction

Hypertension is a growing medical and public health concern globally. In Malaysia, the 2011 National Health and Morbidity Survey<sup>[1]</sup> reported an increased prevalence of hypertension among adults who are above 18 years old from 32.2% (2006) to 32.7% (2011). Interestingly, among the various ethnicities in Malaysia, the indigenous people of Sabah and Sarawak in East Malaysia have the highest (36.4%) prevalence of hypertension followed by the Malays (34.0%), Chinese (32.3%), and Indians (30.6%).<sup>[1]</sup> Moreover, a more recent National Health and Morbidity Survey (2015) report indicated that at least 17.5% of the Malaysian adult population suffer from diabetes mellitus with one third having concurrent hypertension<sup>[2]</sup> which is alarming.

The term prehypertension has been in use since 1920 to 1930 s by insurance companies to refer to a condition of an elevated blood pressure (BP) levels above optimal values and is associated with increased morbidity and mortality.<sup>[3]</sup> This condition leads to an early premorbid change in the future development of hypertension.<sup>[4]</sup> Based on the classical Framingham Heart Study, prehypertensive individuals are 2 times more likely to develop a high BP than those with normal BP.<sup>[5]</sup> In a recent meta-analysis involving 47 cohort studies with 491,666 study participants, Han et al demonstrated that more than 10% reduction of cardiovascular diseases, coronary heart disease, myocardial

infarction, and stroke with an effective control of prehypertension.<sup>[6]</sup>

Prehypertension is known fact to be a precursor to the development of hypertension,<sup>[7]</sup> with a recent finding showing an alarming trend of prehypertension among younger populations. A study in different populations among university students across ASEAN countries<sup>[8]</sup> has indicated an increased prevalence of prehypertension. Similarly, some studies in Malaysia have indicated a high (30.1%–61.1%) prevalence of prehypertension among university students.<sup>[9,10]</sup>

Several factors have been reported to influence the development of prehypertension including environmental and genetic predisposition,<sup>[11,12]</sup> the composition and role of ethnicity may vary based on location. Sabah state is part of Malaysia located in Borneo Island in East Malaysia, with its unique population as compared to West Malaysia (also called Peninsular Malaysia). The indigenous people of Sabah has its own specific genetic make-up, associated with a sociodemographic and cultural background which may confer an impact on their daily lives including health. For example, the Kadazan-Dusun ethnic group is known for their traditional pickled food called 'bosou' consisted of banana tender stems, rice, raw river fish, salt and *pangi* (a local fruit found only in Borneo island) which acts as fermentative agent.

There is a dearth of studies on the prevalence of prehypertension and its associated risk factors among the university students in Sabah. Therefore, a report on the prevalence of prehypertension among university students is timely, in order to determine strategies for the control and prevention of non-communicable diseases like hypertension and cardiovascular diseases. In this study, we aimed to determine the prevalence and modifiable risk factors for prehypertension including sleep duration, body mass index, physical activity and smoking habits among Universiti Malaysia Sabah (UMS) students.

## 2. Materials and methods

### 2.1. Ethical approval

The study was approved by the ethics committee of UMS (ethical no UMS/FPSK6.9/100- 6/1/95) which complies with the Declaration of Helsinki. All students were briefed on the study before their participations. They were allowed to withdraw from the study at any time.

### 2.2. Study site descriptions

UMS is a public university located in the capital city of an eastern Malaysian state of Sabah. There are an estimated 42 ethnic groups with over 200 sub-ethnic groups present in Sabah, with the largest groups being the Kadazan-Dusun, Bajau, and the Murut. Sabahan culture has been influenced by the Bruneian Malays and West Coast Bajau's on the west coast side with Islam being an important part of their lives while Christianity plays an important part to the indigenous cultures in the interior side in the daily lives of the Kadazan-Dusun and Murut. These differences indicate that Sabah is an interesting area to be investigated with its rich cultural background and diversified religious practices.

### 2.3. Study design

The study is a prospective, cross sectional survey, to determine the prevalence of prehypertension and its associated risk factors

among university students at UMS for 4 months duration. The included participants were undergraduates' students aged 18 years and above who consented to participate. Those with histories of chronic illness such as bronchial asthma, thyroid disorders, adrenal or renal pathologies, dyslipidaemias, diabetes mellitus or were on long-standing medications were excluded from the study.

### 2.4. Sampling method

A non-probability convenient sampling method was used to select the university students (2017–2018 intake). They were selected based on convenient accessibility and proximity to the library and hostels cafeteria. A total of 400 undergraduate university students aged 18 years and above were enrolled. However, a total of 5 students with hypertension and 2 students with chronic diabetes were excluded due to the fact that it might affects the end parameters. Although the number of eligible respondents was 395, only 378 students consented to participate. During final analysis of the data, 13 students were further excluded due to incomplete information (Fig. 1). Therefore, a total of 365 students (186 females and 179 males) participated in the study with an overall response rate of 91.25%.

### 2.5. Study questionnaire

The study utilized World Health Organization STEPS-based questionnaire in English language which consisted of three major components

1. General and demographic characteristics
2. Behavioral characteristics
3. Anthropometric and BP measurements.

The sociodemographic section included information such as age, sex, ethnicity, education level, marital status, and the presence of family history of diabetes, hypertension or cardiovascular disease. In the behavioral characteristics, the parameters included were sleep duration, the level of physical activity and smoking habits. The questionnaire was pretested with some slight modifications to the local settings.

### 2.6. Definition of terms

Based on the seventh report of Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure, prehypertension was defined as an individual having a systolic BP reading which ranged between 120 and 139 mmHg or a diastolic BP reading which ranged 80 to 89 mmHg,<sup>[10]</sup> without showing any clinical manifestation.<sup>[13]</sup> Sleep duration was based on the National Sleep Foundation criteria<sup>[14]</sup> with responses recorded as either less than 7 hours per day or more than or equal to 7 hours per day. Physical activity level was based on International Physical Activity Questionnaire scoring protocol<sup>[15]</sup> of the respondents, namely

1. high: a vigorous intensity activity for at least 3 days which achieve a minimum of 1500 metabolic equivalent of task min/week or approximately one hour of activity per day or more with at least a moderate intensity
2. moderate: 5 or more days of moderate intensity activity or walking for at least 30 min/day
3. low: not meeting any of the above-mentioned criteria.

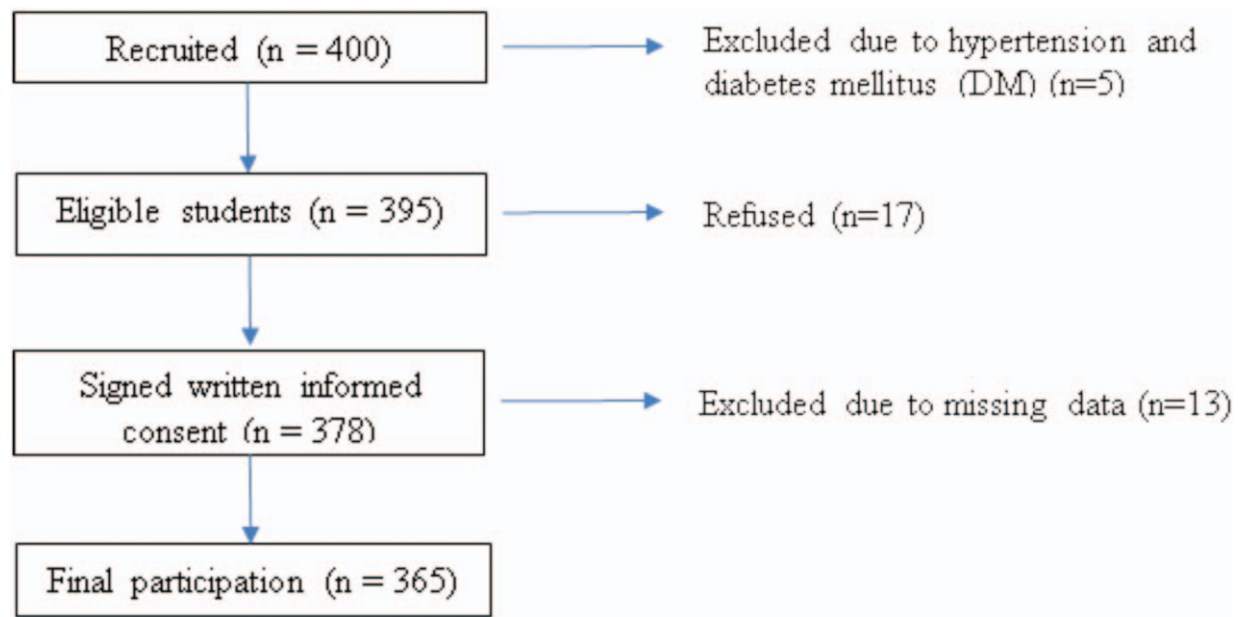


Figure 1. Flow chart of the study.

Smoking habits including whether the students use one or more forms of any tobacco products such as cigarettes, cigars, snuff or chewing tobacco, either occasional or daily and those who never use any forms of tobacco products were recorded. Body mass index (BMI) measurement was based on 2004 Malaysia Clinical Practice Guideline (CPG)<sup>[16]</sup> for obesity and were categorized into 3 groups

1. underweight ( $<18.5 \text{ kg/m}^2$ )
2. normal (BMI  $<18.5$ – $22.9 \text{ kg/m}^2$ )
3. overweight ( $23.0$ – $27.4 \text{ kg/m}^2$ )
4. obese ( $\geq 27.5 \text{ kg/m}^2$ ).

BP was classified according to Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure criteria<sup>[13]</sup> where

1. normal  $<120 \text{ mmHg}$  systolic and  $<80 \text{ mmHg}$  diastolic
2. Prehypertension  $120$  to  $139 \text{ mmHg}$  systolic or  $80$  to  $89 \text{ mmHg}$  diastolic
3. Hypertension  $\geq 140 \text{ mmHg}$  systolic or  $\geq 90 \text{ mmHg}$  diastolic.

### 2.7. Data collection

Trained staff dedicated to the study was involved in data collection. All participating students were asked on previous history of acute or chronic illnesses including hypertension, diabetes, cardiovascular diseases or whether they are on any of medications or treatment. BP measurements were taken in the sitting posture after a 5 minutes rest. The students were comfortably seated on the chair with their feet on the floor and their arms well supported at the level of the heart. BP was measured using an automated digital BP measurement set (Yuwell YE 660B) with an appropriate size of cuff bladder (encircling at least 80% of the arm) to ensure accurate reading. BP was recorded thrice within a 1-minute gap. The mean BP reading was then calculated arithmetically and was taken as the

final reading. Precautionary measures like avoiding any conversation during the measurements were taken to prevent a false increase in BP. Additionally, anthropometric measures like height in meters and weight in kilograms were also measured for BMI calculation. Height was measured without footwear using a stadiometer (SECA, GmbH, Germany), while weight was assessed also without footwear or any heavy accessories using a calibrated weighing scale (SECA, GmbH, Germany).

### 2.8. Data analysis

Data collected was analyzed using IBM Corp. Released 2011, IBM SPSS Statistics for Windows, Version 20.0 while Armonk, NY: IBM Corp, Windows TM version 17.0 was used for statistical analysis. A  $P$  value  $\leq .05$  was considered as statistically significant. Further, chi-square test of association was used to determine the association among the variables. On the other hand, multiple logistic regression analyses were used to assess the significant determinants of prehypertension serving as a dichotomous outcome variable (ie, prehypertension or normotensive) while family history, smoking habits, sleep duration, physical activity and BMI are the independent predictor variables.

## 3. Results

### 3.1. Sociodemographic characteristics

A total of 113 (31%) students were prehypertensive. Alarmingly, 34.1% of the male students were found to be prehypertensive although there was no significant association ( $P = .20$ ) with the female gender seen.

Although numerically, the prevalence of prehypertension was higher among the younger age group (18–20 years) (43%) as compared to those in the older age group (21–24 years) (23%), the difference was not statistically significant ( $P = .13$ ). In terms of ethnicity, the majority of the participating students were Malays

**Table 1**  
**Demographic characteristics of respondents.**

Characteristics	N, % (N=365)	n, % (n=113)	$\chi^2$	P value
Gender				
Female	186 (51.0)	52 (28)		
Male	179 (49.0)	61 (34.1)	1.59	.20
Age (years)				
18–20	144 (39.4)	62 (43)		
21–24	221 (60.5)	51 (23)	2.21	.13
Ethnicity				
Kadazan-dusun	66 (18.1)	26 (39.4)		
Malay	165 (45.2)	52 (31.5)		
Chinese	39 (10.7)	9 (23.1)	5.79	.32
Indian	30 (8.2)	7 (23.3)		
Others	65 (17.8)	19 (29.2)		
Family history				
Diabetes mellitus	36 (9.9)	11 (30.5)		
Hypertension	195 (53.4)	62 (31.8)		
Cardiovascular disease	17 (4.6)	6 (35.2)	0.41	.03
None	117 (32.0)	34 (29)		

N=total number of participated students, n=total no of students who are prehypertensive.

(45.2%), followed by the Kadazan-Dusun (18%) and Chinese (10.6%) which reflects the local demographic data. Nevertheless, the prevalence of prehypertension is highest among the Kadazan-Dusun (39.4%) followed by the Malays (31.5%), although no significant association was seen between ethnicity and prehypertension status ( $P=.32$ ). Additionally, the students had a family history of hypertension (53.4%), diabetes mellitus (9.9%) and cardiovascular diseases (4.6%). Amongst students who were prehypertensive, a family history of cardiovascular diseases (35.2%), hypertension (31.7%) and diabetes (30.5%) were significantly associated with the development of prehypertension ( $P=.03$ ) (Table 1).

**3.2. Anthropometric, BP measurement, and behavioral characteristics**

Overall, there was a higher percentage (78.6%) of students having sleep of less than 7hours duration as compared to students with more than or equal to 7hours sleep (21.4%) (Table 2). Further analysis showed that students having sleep duration of less than 7hours leads to the significant ( $P<.05$ ) development of prehypertension (35.5%) The majority of the students were minimally involved in any physical activity or exercise (63.6%), out of which 45.2% were prehypertensive ( $P<.05$ ). The data is interesting since although most of the students were non-smokers (95.9%), the majority of students (80%) who smokes were found to be prehypertensive ( $P<.05$ ). A higher number of respondents had normal body weight (59.5%), followed by being overweight (25.2%), obese (9%) and underweight (6.3%). An abnormal BMI was significantly associated with prehypertension (where a total of 84.8% and 68.4% were obese and overweight, respectively).

**3.3. Predictors of prehypertension**

Table 3 shows the results of multivariate logistic regression analysis for the predictors of prehypertension. The result shows that a family history of hypertension, having sleep of less than 7hours per day, being obese and overweight, reduced physical

**Table 2**  
**Anthropometric, blood pressure measurement, and behavioral characteristics.**

Characteristics	N, % (N=365)	n, % (n=113)	$\chi^2$	P value
Sleep duration				
<7 h/d	287 (78.6)	102 (35.5)	13.80	.00
≥7 h/d	78 (21.4)	11 (14.1)		
Physical activity				
Low	232 (63.6)	105 (45.2)	60.91	.00
Moderate	133 (36.4)	8 (6)		
Smoking status				
Non-smokers	350 (95.9)	101 (28.8)	17.60	.00
Smokers	15 (4.1)	12 (80)		
BMI category				
Normal weight	217 (59.5)	21 (9.7)	159.02	.00
Under weight	23 (6.3)	1 (4.3)		
Overweight	92 (25.2)	63 (68.4)		
Obese	33 (9.0)	28 (84.8)		

N=total number of participated students, n=total no of students who are prehypertensive.

activity and cigarette smoking are significantly associated with the development of prehypertension.

**4. Discussion**

To the best of our knowledge, this is the first study to determine the prevalence and risk factors for prehypertension among university students in Sabah which was at 31%. Furthermore, the study confirms that the independent risk factors for prehypertension among the university students was family history of hypertension, sleep duration, BMI, physical activity, and smoking habits.

The prevalence of prehypertension in this cohort of undergraduate UMS is comparatively lower than those reported in an earlier study by Shahi et al (31% vs 40.2%).<sup>[17]</sup> Nevertheless, the prevalence reflects the alarming fact that approximately a third of university students have the risk of developing hypertension.

**Table 3**  
**Multivariate analysis on the association of prehypertension.**

Characteristics	P value	aOR <sup>a</sup>	95%CI
Family history			
Hypertension	.00	2.30	1.24–4.28
Diabetes		1.00	–
Cardiovascular disease		1.00	
None		1.00	
Sleep duration			
<7h/d	.00	1.82	1.39–2.46
>7h/d		1.00	–
BMI category			
Underweight		1.00	–
Normal weight		1.00	1.42–2.15
Over weight	.00	1.75	2.75–5.72
Obese	.00	3.88	
Physical activity			
Low	.00	3.43	3.30–5.48
Moderate		1.00	–
Smoking status			
Non-smoker		1.00	–
Smoker	.00	1.78	1.20–2.90

<sup>a</sup>aOR = adjusted Odd ratio, <sup>b</sup>CI = confidence interval.

Interestingly, Cheah et al who also conducted a study among university students, albeit in Sarawak, East Malaysia<sup>[18]</sup> reported a lower prevalence of prehypertension (8.7%). This is surprising since similar like Sabah, Sarawak is a state that is located on the Borneo Island and therefore tend to have similar cultural and sociodemographic background. It is plausible that the variation seen may be contributed by the different types of BP monitors used (automated digital BP measurement set used in the current study versus Omron HBP-1100 Professional Portable BP monitor used by Cheah et al). This means, the interpretation of significantly variable prevalence of prehypertension among students across Asian countries, for instance 30.1% in Malaysia,<sup>[10]</sup> 5.1% in Indonesia,<sup>[19]</sup> 13.9% in the Philippines,<sup>[20]</sup> and 18% in Laos, Myanmar, and Thailand, respectively<sup>[8]</sup> should not underestimate the type of BP monitors used.

Several risk factors have been reported to have a significant effect on the development of prehypertension. The current study showed the association of family history hypertension and predisposition for subsequent development of prehypertension. It has been reported previously that prehypertension is a non-modifiable risk factor for the development of systemic vascular disease.<sup>[21]</sup> Often, university students are generally active and healthy, therefore, prehypertension may not be discovered until late. Thus, early identification of prehypertension among young university students with a family history of hypertension will be useful to help advice “risky students” for more frequent monitoring of BP as an early intervention.

In this study, it was also shown that having inadequate sleep duration predisposed an individual to the development of prehypertension. The result is similar to that conducted among Asian<sup>[22]</sup> and European populations.<sup>[23]</sup> In an interesting study conducted by Hafeez I<sup>[9]</sup> among pre-university students showed that those with poor sleep quality were 2 times more likely to have prehypertension. In our study, the plausible reason of lack of sleep among university students may be attributed to staying up late in order to complete assignments or to prepare for examination. It is also possible that students have the habit of excessive usage of internet at night for various reasons.

Many studies have shown that obesity is associated with cardiovascular, metabolic, and renal disorders. Similarly, in our study, a very high number of the prehypertensive students were obese (84.8%) and overweight (68.4%). Comparable findings were also seen on the prevalence of prehypertension and its obesity among undergraduate students at a tertiary institution in Ghana.<sup>[24]</sup> Some authors however have argued on the importance of abdominal obesity to be a good predictor of prehypertension and hypertension<sup>[25]</sup> as opposed with subcutaneous fat measurement in BMI. Since in our current study, BMI was utilized, it would be interesting to explore on these differences in future studies. It is a worrying phenomenon in Malaysia, whereby carbohydrate followed by high-fat foods and proteins dominated the school cafeteria.<sup>[26]</sup> This contributes to rising of obesity in addition to the consumption of heavy meals late at night among the students. Therefore, early interventions including conducting health seminars on proper diet and lifestyle modifications such as weight loss may be an effective way to ameliorate the risk of prehypertension development.

As also previously reported, students with pre-hypertensive BP have less to moderate physical activity with reduced exercise.<sup>[27]</sup> Interestingly, although this was not our main area of investigation, we found that physical activity is the strongest modifiable predictor to the development of prehypertension. It should also

be noted that the study was conducted just a few weeks before the students’ final examinations. Therefore, there may be several reasons to the lack in physical activity including unavailability of time, overburdened with studies and examination stress. Interestingly, in this study, although the majority of the students were aware of the importance of physical activity, only a few actually understand that regular and adequate physical activity has some benefits in preventing onset of prehypertension. It is an important precaution to students engaging in moderate physical exercise in this cohort (36.4%) to have appropriate physical activity duration as long-term and sustained physical activity may also increase the risk for hypertension.<sup>[28]</sup>

It is a known fact that smoking habits lead to an increase in the risk of atherosclerosis development which in turns affects the BP and may contribute to increased risk of hypertension and myocardial infarction. Although our study indicated that only 4.1% of the student smokes, there was still also a clear association with the risk of prehypertension. Similarly, Hafeez I, et al<sup>[9]</sup> established a significant association between tobacco use and prehypertension among university students. The contributing factors for engaging in smoking among the students are largely due to social factors. Students may be under the false impression that smoking eliminates stress while some followed in the footsteps of their friends “just for fun”. Additionally, students living away from their parents are more influenced by their peers in terms of lifestyles.

Surprisingly, we did not observe any significant association between gender and prehypertension. This is in contrast with other reports<sup>[29]</sup> which highlighted the association with the male gender with the development of prehypertension since males in most regions of the world tend to have a higher tendency for smoking, alcohol consumption and tobacco use. We hypothesized that the disproportionate gender participations between studies which could have contributed to the differences seen.

## 5. Limitations

The main limitation of this study was taking BP measurements at any time of the day, since BP has circadian variations. Secondly, since our study was conducted only among undergraduate students aged 18 to 24 years only, comparison with other studies involving post-graduate students cannot be done. Finally, the information collected was based on self-reporting, and therefore there is a possibility of under-reporting.

### 5.1. Future direction

University students with their higher educational levels should expand their knowledge about BP and should develop more healthy lifestyles in order to prevent hypertension since they will be future leaders of the country. As such, intervention programs aiming at prevention of prehypertension should be targeted to younger age groups including university students. Future studies should incorporate investigations of fasting plasma glucose, total cholesterol, low density lipoprotein and high-density lipoprotein levels for a better understanding of prehypertension.

## 6. Conclusion

This study revealed a higher prevalence of prehypertension among the university students as compared other study conducted in Malaysia, a relatively understudied group of

population. In addition, our study also confirmed the importance of sleep, physical activity, BMI and smoking as a predisposing negative factor for the development of prehypertension.

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## References

- Naing C, Yeoh P, Wai V, et al. Hypertension in Malaysia. *Medicine* 2006;95:e2417.
- Ab Majid N, Omar M, Khoo Y, et al. Prevalence, awareness, treatment and control of hypertension in the Malaysian population: findings from the National Health and Morbidity Survey 2006–2015. *J Hum Hypertens* 2018;32:617–24.
- Zimlichman R, Julius S, Mancina G. History of prehypertension: past and present, a saga of misunderstanding and neglect. Switzerland: Springer, Cham; 2019. 17–26.
- Haller H, Bertram A, Stahl K, et al. Early changes in renal vasculature in prehypertension. Switzerland: Springer, Cham; 2019. 149–157.
- Parikh NI, Pencina MJ, Wang TJ, et al. A risk score for predicting near-term incidence of hypertension: the Framingham Heart Study. *Ann Intern Med* 2008;15:102–10.
- Han M, Li Q, Liu L, et al. Prehypertension and risk of cardiovascular diseases: a meta-analysis of 47 cohort studies. *J Hypertens* 2019;37:2325–32.
- Doumas M, Katsiki N, Mikhailidis DP. Prehypertension, the risk of hypertension and events. Switzerland: Springer, Cham; 2019. 37–55.
- Peltzer K, Pengpid S, Sychareun V, et al. Prehypertension and psychosocial risk factors among university students in ASEAN countries. *BMC Cardiovasc Disord* 2017;17:230.
- Mohd Hafeez I, Salmiah MS, Saliluddin MS. Pre hypertension and its associated risk factors among students in pre-university college in Malaysia. *Int J Public Health Clin Sci* 2016;3:70–85.
- Salmiah MS, Balami AD, Zulkefli NAM. Association of behavioural factors, body mass index status, family history of hypertension and prehypertension among a public university students in Malaysia. *Int J Public Health Clin Sci* 2014;1:109–20.
- Simicevic L, Milicic B, Josipovic J, et al. Frequency of AGT, ACE, AGTR1, ADRB1, UMOD AND ADIPOQ genetic polymorphism in prehypertension. *J Hypertens* 2019;1:37.
- Hill LK, Thayer JF. The autonomic nervous system and hypertension: ethnic differences and psychosocial factors. *Curr Cardiol Rep* 2019; 21:15.
- 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; 21:2560–71.
- Hirshkowitz M, Whiton K, Albert SM, et al. National Sleep Foundation's updated sleep duration recommendations: final report. *Sleep Health* 2015;1:233–43.
- Tran DV, Lee AH, Au TB, et al. Reliability and validity of the International Physical Activity Questionnaire–Short Form for older adults in Vietnam. *Health Promot J Aust* 2013;24:126–31.
- Zainudin S, Daud Z, Mohamad M, et al. A summary of the Malaysian clinical practice guidelines on management of obesity 2004. *J ASEAN Fed Endocr Soc* 2014;26:101.
- Shahi M, Li CW. Prehypertension and its correlation with cardiovascular risk factors—a study among health sciences students in Malaysia. *J Integ Health Sci* 2013;1:104.
- Cheah WL, Ensayan JM, Helmy H, et al. Hypertension and its association with Anthropometric indices among students in a public university. *Malays Fam Phys* 2018;13:2.
- Atika V, Wihardja R, Sari KI. Body Mass Index and Its Relation to Blood Pressure in Preclinical Students of the Faculty of Dentistry, Padjadjaran University. In: *11th International Dentistry Scientific Meeting (IDSMSM 2017) 2018*. Available at: <https://doi.org/10.2991/idsm-17.2018.32>. Accessed on 24 October 2019.
- Pengpid S, Peltzer K, Ferrer AJ. Prehypertension and associated factors among university students in the Philippines. *Int J Adolesc Med Health* 2014;26:245–52.
- Amaral JF, Borsato DD, Freitas IM, et al. Autonomic and vascular control in prehypertensive subjects with a family history of arterial hypertension. *Arquivos Bras Cardiol* 2018;110:166–74.
- Lu K, Ding R, Tang Q, et al. Association between self-reported global sleep status and prevalence of hypertension in Chinese adults: data from the Kailuan community. *Int J Environ Res Public Health* 2015;12:488–503.
- Bruno RM, Palagini L, Gemignani A, et al. Poor sleep quality and resistant hypertension. *Sleep Med* 2013;14:1157–63.
- Gyamfi D, Obirikorang C, Acheampong E, et al. Prevalence of prehypertension and hypertension and its related risk factors among undergraduate students in a Tertiary institution, Ghana. *Alex J Med* 2018;54:475–80.
- Rivera-Mancía S, Colín-Ramírez E, Cartas-Rosado R, et al. Indicators of accumulated fat are stronger associated with prehypertension compared with indicators of circulating fat. *Medicine* 2018;97:e11869.
- Muda WM, Jamil NI, Hanafi NN, et al. How healthy is competitive food served at primary school canteen in Malaysia. *Int Med J* 2017;24:44–7.
- Chan YY, Teh CH, Lim KK, et al. Lifestyle, chronic diseases and self-rated health among Malaysian adults: results from the 2011 National Health and Morbidity Survey (NHMS). *BMC Public Health* 2015;15:754.
- Zhu Z, Feng T, Huang Y, et al. Excessive physical activity duration may be a risk factor for hypertension in young and middle-aged populations. *Medicine* 2019;98:e15378.
- Agho KE, Osuagwu UL, Ezech OK, et al. Gender differences in factors associated with prehypertension and hypertension in Nepal: a nationwide survey. *PLoS One* 2018;13:e0203278.