The Association Between Risk Factors and Hypertension in Perak, Malaysia

K W Loh, F Rani, T C Chan, H Y Loh, C W Ng, F M Moy

Julius Centre University of Malaya, Department of Social & Preventive Medicine, Faculty of Medicine, University of Malaya, 50603 Kuala Lumpur, Malaysia

SUMMARY

Introduction: Hypertension is a major public health problem in Malaysia. A survey was initiated to examine the association of modifiable and non-modifiable risk factors for hypertension in Perak, Malaysia.

Methods: A total of 2025 respondents aged 30 years and above were recruited using a multi-stage sampling method. Hypertension was defined as self-reported hypertension and/or average of two blood pressure readings at single occasion with SBP ≥ 140mmHg or DBP ≥ 90 mmHg. Body mass index (BMI) was defined using the Asian criteria and International Physical Activity Questionnaire (IPAQ) was used to evaluate physical activity. Body weight, height and blood pressure were obtained using standard procedures. Univariate analyses were conducted to examine the associations between risk factors and hypertension. Multiple logistic regression was used to examine each significant risk factor on hypertension after adjusted for confounders.

Results: In total, 1076 (54.9%) respondents were found to be hypertensive. Significant associations (p <0.001) with hypertension were noted for increasing age, low physical activity, obese BMI, no education background and positive family history of hypertension. After adjusting for age, sex, ethnicity, education background, family history, BMI, physical activity, smoking and diet, respondents who were obese and had positive family history had higher odds for hypertension (OR:2.34; 95% CI:1.84-3.17 and 1.96 (1.59-2.42) respectively. A significant increase (p <0.001) in risk for hypertension was noted for age. Those with moderate physical activities were 1.40 (1.04-1.78) times more of having hypertension than those active. Poor diet score and smoking were not significantly associated with increased risk for hypertension.

Conclusion: In conclusion, modifiable risk factors such as BMI and physical activity are important risk factors to target in reducing the risk for hypertension.

KEY WORDS:
Hypertension, obesity, BMI, IPAQ, smoking, Malaysia

INTRODUCTION

Cardiovascular disease (CVD) is responsible for one-third of all deaths worldwide [1]. It was estimated that approximately 7.1 million deaths per year may be attributable to hypertension [2]. The independent relation of hypertension to CVD has been well-established in many epidemiological studies over the past decades [3]. Hypertension continues to be a major public health problem in Malaysia because of its high prevalence and an important risk factor for cardiovascular morbidity and mortality [4]. Consequently, the management of hypertension appears to be one of the major therapeutic goals.

Epidemiological studies have identified a number of risk factors underlying hypertension, which can be collectively classified into modifiable and non-modifiable factors. Age, gender, ethnicity and heredity are notable non-modifiable risk factors. Modifiable risk factors include smoking , physical inactivity, obesity and diet high in saturated fats [5,6]. A multifactorial approach to the treatment of hypertension is often indicated as these factors tend to interact with one another. A number of cohort studies and randomized clinical trials have demonstrated that the risks from hypertension can be partly reversed [7]. Effective intervention includes weight loss, reduce sodium intake, moderate alcohol consumption, adequate potassium supplementation, increased physical activity and consume a diet rich in fruits, vegetables, and low-fat dairy products and reduced in saturated and total fat[8].

The aim of this study was to examine the associations of both modifiable and non-modifiable risk factors for hypertension in 5 locations in Perak, Malaysia. The findings of this study can provide important information in planning preventive measures for hypertension in the country.

PATIENTS AND METHODS

Study Population

A population-based cross-sectional household survey was initiated in Perak, Malaysia. This was a pilot study conducted at five sampling locations (Gerik, Kampar, Kuala Kangsar, Parit Buntar and Taiping). Four villages were selected from each sampling location and further, a number of households were selected from each village proportionate to their respective sizes by random sampling. For each household, the interviewer determines the household composition and identifies all adults aged 30 years and above. The eligible individuals were invited to participate in face-to-face interviews by trained interviewers after written consent was obtained.

This article was accepted: 11 June 2013
Corresponding Author: Loh Kwong Weng, Julius Centre University of Malaya, Department of Social & Preventive Medicine, Faculty of Medicine, University of Malaya, 50603 Kuala Lumpur, Malaysia Email: melvinloh@gmail.com

In the event of an unsuccessful interview, the interviewer knocked on the immediate next household on the left until a successful interview was achieved. After obtaining their written consent, all respondents aged 30 years and above were interviewed by trained interviewers. Information on demographic variables, education background, cigarette-smoking habits, dietary habits, physical activity and medical history was obtained using a pre-tested standardized questionnaire.

Body weight and height measurements were taken by trained observers according to a standard procedure using standardized equipment which was calibrated before use. Specific quality checks were conducted to ensure the quality of the data collected. Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in metres. Participants' BMI scores were categorized using the World Health Organization Asian criteria[9] : underweight (BMI<18.5kg/m^2), normal (BMI=18.5 to 22.9 kg/m^2), overweight (BMI=23.0 to 26.9 kg/m^2) and obese (BMI ≥ 27.0 kg/m^2)

Blood pressure was taken manually using mercury sphygmomanometer and stethoscope (Littmann) in accordance to recommendations by the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure [10]. Two blood pressure measurements were obtained from each respondent in a sitting position in their respective residence. The average of these two readings was used to classify an individual. Written consent was obtained from each respondent. The study protocol was approved by the Ethical Review Board of Faculty of Medicine, University of Malaya.

Hypertension was defined as those who have reported hypertension and is currently on anti-hypertensive medication and those who were detected to be hypertensive through medical examination with an average of two blood pressure readings at single occasion with SBP ≥ 140mmHg and/or DBP ≥ 90 mmHg. Previous studies supports that self-reported hypertension is a relatively valid tool to assess the hypertensive status of study participants [11]. The second criterion used in this screening examination has also been practiced in a national study [12].

The assessment of food intake practices was conducted using a set of questionnaire provided by the Ministry of Health, Malaysia [13]. The questions ranged from frequency of food intake daily, to frequency of intake of red meat, fish, fried food and fruits. Each respondent is classified into one of 4 diet score groups: 0-3 (Poor), 4-7 (Moderate), 8-11 (Good) and 12-16 (Excellent).

Physical activity was evaluated using IPAQ (International Physical Activity Questionnaire) [14] where METS (metabolic equivalent score) was computed. The IPAQ assesses physical activity undertaken across a comprehensive set of domains including leisure time, domestic and gardening (yard) activities, work-related and transport-related activity. Each respondent was classified into 3 categories: high, moderate or low-intensity.

Smoking is the inhalation of the smoke of burning tobacco encased in cigarettes, pipes, and cigars. In this study, we grouped the respondents into 3 categories; non-smokers for those who have never smoked or smoked a few puffs but never smoked again; smokers for those who smoke rarely, occasionally or daily; and ex-smokers for those who used to smoke but now have stopped.

Statistical Analyses

All data were entered and analyzed using the SPSS Program version 16. Participants' characteristics were described accordingly. Univariate analyses using Pearson χ^2 test were conducted to examine the associations between each risk factor and hypertension. Significant level was preset at 0.05. The association between hypertension and each significant risk factor was investigated after adjusted for age, sex, ethnicity, education background, family history, BMI, physical activity, smoking and diet using Multiple Logistic Regression model. The odds ratios (OR) and the 95% confidence intervals (CI) are summarized in Table II.

RESULTS

The total number of respondents aged 30 years and above was 2025. The majority (69.6%) of our respondents were aged 40 to 69 years. About half (56.8%) of the respondents were females.

In total, 54.9% respondents were found to be hypertensive of which 31.5% respondents were self-reported whereas 23.4% respondents were detected during medical examination. Prevalence of obese BMI (>27 kg/m^2) was the highest (35.6%), followed closely by overweight BMI (23.0-26.9 kg/m^2) (33.7%). Female respondents had higher obesity prevalence at 41.6% than men at 22.7%. A majority of respondents were non-smokers (75.9%) and practiced high physical activity (38.9%). Among those with self-reported hypertension, about one-half respondents (48.5%) reported to be hypertensive despite medication. Table I showed that the prevalence of hypertension increased with age and BMI respectively.

The adjusted odds (aOR) of hypertension increased as age increased. Obese individuals (BMI ≥ 27.0 kg/m^2) had the odds of 2.3 times to have hypertension than individuals with a normal BMI (aOR: 2.34, 95% CI: 1.84-3.17). The aOR of individuals with positive family history of hypertension had nearly 2 times increased odds of having hypertension compared to those without a family history of hypertension (aOR 1.96, 95% CI: 1.59-2.42). Individuals with moderate physical activity were 1.40 times of having hypertension (aOR: 1.40, 95% CI: 1.04-1.78.). Poor diet score, smoking and education background were not statistically associated with hypertension.

DISCUSSION

CVD has been the leading cause of death in Malaysia for nearly 5 decades. Large population-based cohort studies have demonstrated a continuous, consistent and graded relationship between blood pressure and subsequent detrimental sequelae of various atherosclerotic events [15]. The risk of heart attack, heart failure, stroke and kidney diseases increases with rising blood pressure. This is further compounded by additional risk factors such as smoking, diabetes mellitus and dyslipidaemia [16]. The Third National Health and Morbidity Survey (NHMS III) in Malaysia was

Table I: Bivariate analyses between risk factors for hypertension and hypertension

Variables	Hypertensive		Non-hypertensive		p-value
	n	(%)	n	(%)	
SOCIODEMOGRAPHY					
Age group	n=1961				<0.001
30-39	68	(26.5)	189	(73.5)	
40-49	178	(43.5)	231	(56.5)	
50-59	286	(53.7)	247	(46.3)	
60-69	300	(69.8)	130	(30.2)	
70-79	189	(71.9)	74	(28.1)	
≥80	55	(79.7)	14	(20.3)	
Sex	n=1961				0.413
Male	458	(53.8)	393	(46.2)	
Female	618	(55.7)	492	(44.3)	
Ethnicity	n=1961				0.032
Malay	860	(55.8)	682	(44.2)	
Chinese	163	(55.1)	133	(44.9)	
India	38	(48.7)	40	(51.3)	
Others	15	(33.3)	30	(66.7)	
Education background*	n=1959				<0.001
Yes	875	(53.0)	776	(47.0)	
No	201	(65.3)	107	(34.7)	
BMI, kg/m²	n=1922				<0.001
Underweight	40	(41.7)	56	(58.3)	
Normal	240	(49.0)	250	(51.0)	
Overweight	335	(51.4)	517	(48.6)	
Obese	431	(63.0)	253	(37.0)	
LIFESTYLE					
Physical activity (IPAQ) [γ]	n=1860				<0.001
Low	300	(58.8)	210	(41.2)	
Moderate	309	(61.4)	196	(38.8)	
High	409	(48.4)	436	(51.6)	
Diet Score [α]	n=1954				0.514
Excellent	730	(55.4)	588	(44.6)	
Good	321	(53.1)	284	(46.9)	
Moderate	15	(57.7)	11	(42.3)	
Poor	4	(80)	1	(20)	
Smoking	n=1945				0.001
Non-smoker	825	(56.2)	644	(43.8)	
Smoker	163	(46.3)	189	(53.7)	
Ex-smoker	76	(61.3)	48	(38.7)	
DISEASE PREVALENCE					
Family history of hypertension	n=1920				<0.001
Yes	512	(61.7)	318	(38.3)	
No	536	(49.2)	553	(50.8)	

*Education background is defined as Yes if a respondent has had previous exposure to formal education (Primary education, secondary education or tertiary education).

[γ] Physical activity was evaluated using IPAQ; the international physical activity questionnaire, where metabolic equivalent score (METS) was computed.

[α] The assessment of food intake practices was conducted using a set of questionnaire provided by the Ministry of Health, Malaysia. The questions ranged from frequency of food intake daily, to frequency of intake of red meat, fish, fried food and fruits.

carried out in 2006 and reported the prevalence of hypertension to be 43% among respondents aged ≥ 30 years. The present study used the similar methods for blood pressure taking as the NHMS in 2006, and found that the prevalence of hypertension in the same group is relatively higher in Perak at 54.9% in 2011. This could be attributed to a larger sample of elderly participants in the study sample.

Data from the NHMS III study showed that the prevalence of obese category was 17.4% (95% CI: 16.7–18.0) for women and 10.0% (95% CI: 9.5–10.5) for men. Our study showed a higher prevalence at 41.6% for woman and 22.7% for men. This difference could be attributed to different age population of our sample and different BMI cut-off figures adopted. The NHMS III used the higher conventional BMI cut-off figures whereas our study followed the revised cut-off points recommended by the WHO Expert Consultation for Asians [17]. Recent studies have shown that many Asian populations have higher percentage of body fat compared to Caucasians of the same age, gender and BMI [18]. Hence, the risk factors for cardiovascular diseases at a given BMI are generally higher among Asian populations.

The prevalence estimates of hypertension were slightly higher among females (56%) than males (54%). This study concurs with the NHMS III in 2006 that women were more likely to be

Table II: Crude & Adjusted Odds Ratio of Risk Factor associated with Hypertension

		Crude OR	95% CI	Adjusted OR	95% CI
Age group	30-39	1.00		1.00	
	40-49	2.14	1.53-3.01	2.26	1.56-3.29
	50-59	3.22	2.33-4.46	3.37	2.35-4.83
	60-69	6.41	4.54-9.06	7.91	5.35-11.69
	70-79	7.10	4.83-10.44	9.17	5.86-14.33
	≥ 80	10.92	5.71-20.89	12.42	6.01-25.67
Sex	Male	1.00		1.00	
	Female	1.08	0.90-1.29	0.82	0.64-1.06
Ethnicity	Malay	2.52	1.35-4.73	1.48	0.72-3.04
	Chinese	2.45	1.27-4.75	1.25	0.59-2.66
	India	1.90	0.89-4.07	1.13	0.47-2.70
	Others	1.00		1.00	
Education background	Yes	1.00		1.00	
	No	1.67	1.29-2.15	1.25	0.92-1.71
Family history	Yes	1.66	1.38-2.00	1.96	1.59-2.42
	No	1.00		1.00	
BMI, kg/m^2	Underweight	0.75	0.48-1.16	0.63	0.36-0.98
	Normal	1		1	
	Overweight	1.10	0.87-1.39	1.14	0.90-1.52
	Obese	1.78	1.40-2.25	2.34	1.84-3.17
Physical activity (METscore)	Low	1.52	1.34-2.10	1.14	0.88-1.47
	Moderate	1.68	1.27-1.95	1.40	1.04-1.78
	High	1.00		1.00	
Smoke	Non-smoker	1.00		1.00	
	Smoker	0.67	0.53-0.85	0.75	0.55-1.04
	Ex-smoker	1.24	0.85-1.80	0.83	0.53-1.30
Diet Score	Excellent	1.00		1.00	
	Good	0.91	0.75-1.10	0.93	0.75-1.17
	Moderate	1.10	0.50-2.41	1.47	0.40-3.58
	Poor	3.22	0.36-28.90	3.10	0.28-33.91

BMI = Body mass index
CI = Confidence interval
OR = Odds ratio

hypertensive (43.4%) than males (41.7%). The effect of oestrogen on blood pressure remained controversial [19].

The NHMS III in 2006 reported the prevalence of hypertension was highest among the Malays (45.4%), followed by Chinese (40.6%) and Indian (40.0%). In this study, there was a similar estimated prevalence of hypertension between the different ethnic groups; however these differences were not statistically significant. The differences in prevalence between ethnic groups are most likely an interplay between their different genetic and environmental factors. There is clinical evidence to suggest that normotensive Malays may have higher sensitivity of beta-adrenergic receptor compared with Chinese and Indians [20]. Higher beta-adrenergic receptor sensitivity has been linked with increased risk for hypertension in several studies [21].

Individuals with a family history of hypertension are twice as likely to have hypertension. Family history of hypertension has been recognized as among the strongest predictors for developing hypertension in later life [22]. Previous studies have confirmed that elevated insulin level , higher insulin resistance and higher LDL cholesterol were all associated with family history of hypertension [23,24]. These finding underscores the importance of screening family members for hypertension when an index case is found. In addition, identification of individuals at risk for hypertension allows early intervention through diet and lifestyle changes. Thus, future incidence of cardiovascular diseases may be reduced as well.

Among individuals with an education background, 53.0% were hypertensive compared to the corresponding value reported in NHMS III which was 58.6%, although no significant association between hypertension and education background was noted in our study. However, in some studies, low education level was significantly associated with increased risk of hypertension, potential consequences of hypertension and knowledge regarding nonmedical treatment options [25], but not all [26].

Physical inactivity has been associated with an increased risk of cardiovascular disease in epidemiologic studies [27]. Our study revealed significantly lower odds for hypertension among individuals with high level of physical activity as compared to moderate and low level of physical activity. Interestingly, those with moderate physical activities have additional of 40% odds of getting hypertension when compared to those with high physical activity. There was no significant association observed between low physical activity and hypertension. A possible reason is that the IPAQ questionnaire may not be sensitive enough to measure low physical activity [28]. Substantial evidence by Sobngwi *et al* [29] suggested that walking and vigorous exercises were associated with substantial reductions in cardiovascular events like hypertension. It was found that increasing level of physical activity improves blood flow and helps to reduce the resting heart rate and blood pressure [30].

Smoking is associated with chronic low-grade inflammation and arterial stiffness [31], which are associated with hypertension [32]. In our study, smoking was not significantly and independently related to hypertension. Some population studies in the literature reported similar findings [26], but some others do not [33]. The distribution pattern of prevalence of non-smokers, smokers and ex-smokers in our survey mirrored that of the data from NHMS III, whereby non-smokers are highest at 72.9%, followed by smokers (21.6%) and ex-smokers 5.5%)

In our study, smokers had lower odds of having hypertension (OR 0.67, 95% CI 0.53-0.85) as compared to non-smokers in the univariate analysis, which was later proven to be insignificant (OR 0.75, 95% CI 0.55-1.04) in the multivariate analysis. This could be attributed to a larger proportion of smokers in the younger age population (67.3% aged 30-59) which may not have had significant side effect to cause hypertension. After adjustment was made, it appears that effect of smoking on hypertension is not significant.

There was a change in direction of association among the ex-smokers in the univariate analysis (OR 1.24; 95% CI 0.85-1.80) and in the final model (OR 0.83, 95% CI 0.53-1.30). We believe that ex-smokers were likely to stop smoking due to health reasons, and as such, they faced a higher risk for comorbidity, which explains the higher odds for having hypertension. However, as the proportion of ex-smoker is very low (6.2%), the change in direction of association in the multivariate analysis were most likely attributed to the effect of BMI as 67.2% of ex-smokers were overweight or obese. A prospective cohort study suggested that cigarette smoking may be a modest but important risk factor for the development of hypertension [34] however this being a cross-sectional study, it becomes our limitation in associating smoking with hypertension.

Poor diet score was not significantly associated with increased risk for hypertension. The failure of our study to support findings relating dietary intake to the development of hypertension may be attributable to imprecision in the measurement of dietary data and unavailability of a validated food frequency questionnaire. The dietary score used in our study was mainly to assess general diet but not hypertension per se.

Hypertension is projected to be a serious public health challenge well into 2025, with an estimated 1.56 billion people (29% of world's adult population) suffering from it [35]. It has been suggested that men and women have similar overall prevalence of hypertension, and that such prevalences increased with age were found to be consistent in all world regions [35]. Although improvements have been made in detection and treatment in some countries, the global rates of blood pressure control were found to be generally poor and even worse in the developing nations [36].

As Malaysia is a developing country, epidemiological transition is taking place with a decline in communicable diseases and an increase in non-communicable disease, thus facing the daunting prospects of even higher prevalence in the future. A study previously done in Malaysia has shown that levels of awareness, treatment and control were low [4].

There is an urgent need for a comprehensive awareness campaigns with concerted effort that focuses on several modifiable risks to health, in particular physical inactivity and high body-mass index. Improvement in access to medical care may also lead to better control of hypertension.

LIMITATION

A potential limitation of our study was that its cross-sectional design may limit our ability to infer a causal relationship between significant risk factors and hypertension. The instrument has not yet been formally translated. Although interviewers were able to translate it during the interviews as required, misinterpretation of the questions by the respondents may lead to information bias. An interpersonal variance may occur during measurement. The standardized assessment of food intake practices provided by the Ministry of Health, Malaysia did not include information about dietary salt intake, which was known to increase the risk of hypertension [37].

CONCLUSION

Modifiable risk factors such as BMI and physical activity are important factors to target in reducing the risk for hypertension. Effective preventive programs include educating the public on the dangers of hypertension, encourage weight reduction and exercise, practising a healthy lifestyle consisting of a balanced diet that follows the food pyramid, increase awareness on the effects of smoking and promote regular medical checkups for those with positive history of hypertension and of older age group should be implemented.

ACKNOWLEDGEMENT

We would like to acknowledge the Department of Social and Preventive Medicine, University of Malaya for supporting this study. We wished to thank the District Health Officers, and Medical Officers of Health of the relevant districts whom had given permission to conduct the study in the districts. Not forgetting also our respondents, the staff of the District Health Office, and our colleagues who assisted in data collection.

REFERENCES

1. World Health Organization. The World Health Report 2002: Reducing Risks, Promoting Healthy Life. Geneva: World Health Organisation; 2002.
2. Singh RB, Suh IL, Singh VP, *et al.* Hypertension and stroke in Asia: prevalence, control and strategies in developing countries for prevention. Journal of human hypertension. Oct-Nov 2000; 14: 749-63.
3. Vasan RS, Larson MG, Leip EP, *et al.* Impact of high-normal blood pressure on the risk of cardiovascular disease. The New England journal of medicine. 2001; 345 :1291-7.
4. Rampal L, Rampal S, Azhar MZ, *et al.* Prevalence, awareness, treatment and control of hypertension in Malaysia: A national study of 16,440 subjects. Public Health. 2008; 122: 11-8.
5. Blair SN, Goodyear NN, Gibbons LW, *et al.* Physical fitness and incidence of hypertension in healthy normotensive men and women. JAMA: the journal of the American Medical Association. 1984; 252: 487-90.
6. Sun Z, Zheng L, Detrano R, *et al.* Incidence and predictors of hypertension among rural Chinese adults: results from Liaoning province. Annals of family medicine. 2010; 8: 19-24.
7. Klag MJ, Whelton PK, Randall BL, *et al.* Blood pressure and end-stage renal disease in men. The New England journal of medicine. 1996; 334: 13-8.
8. Whelton PK, He J, Appel LJ, *et al.* Primary prevention of hypertension: clinical and public health advisory from The National High Blood Pressure Education Program. JAMA : the journal of the American Medical Association. Oct 16 2002;288(15): 1882-8.
9. WHO/IASO/IOTF. The Asia-Pacific perspective: redefining obesity and its treatment. Melbourne: Health Communications Australia; 2000.
10. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. Bethesda; 2004.
11. Alonso A, Beunza JJ, Delgado-Rodriguez M, *et al.* Validation of self reported diagnosis of hypertension in a cohort of university graduates in Spain. BMC public health. 2005; 5: 94.
12. The Third National Health and Morbidity Survey 2006. Institute for Public Health, Ministry of Health, Malaysia.
13. Modul Pakej Makan Secara Sihat. Malaysia: Ministry of Health, Malaysia; 2005.
14. Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire (IPAQ).
15. Kannel WB. Blood pressure as a cardiovascular risk factor: prevention and treatment. JAMA : the journal of the American Medical Association. 1996;275 :1571-1576.
16. Chobanian AV, Bakris GL, Black HR, *et al.* Seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. Hypertension. 2003;42 :1206-52.
17. Choo V. WHO reassesses appropriate body-mass index for Asian populations. Lancet. 2002; 360: 235.
18. Deurenberg-Yap M, Schmidt G, van Staveren WA, *et al.* The paradox of low body mass index and high body fat percentage among Chinese, Malays and Indians in Singapore. International journal of obesity and related metabolic disorders : journal of the International Association for the Study of Obesity. 2000;24: 1011-7.
19. Ashraf MS, Vongpatanasin W. Estrogen and hypertension. Current hypertension reports. 2006; 8: 368-76.
20. Rasool AH, Rahman AR, Ismail R, *et al.* Ethnic differences in response to non-selective beta-blockade among racial groups in Malaysia. International journal of clinical pharmacology and therapeutics. 2000; 38: 260-9.
21. Mills PJ, Dimsdale JE, Ziegler MG, *et al.* Racial differences in epinephrine and beta 2-adrenergic receptors. Hypertension. 1995; 25: 88-91.
22. Williams RR, Hunt SC, Hasstedt SJ, *et al.* Are there interactions and relations between genetic and environmental factors predisposing to high blood pressure? Hypertension. 1991; 18(3 Suppl): I29-37.
23. Grandi AM, Gaudio G, Fachinetti A, *et al.* Hyperinsulinemia, family history of hypertension, and essential hypertension. Am J Hypertens. 1996; 9(8): 732-8.
24. Lopes HF, Silva HB, Soares JA, *et al.* Lipid metabolism alterations in normotensive subjects with positive family history of hypertension. Hypertension. 1997;30: 629-31.
25. Hoang VM, Byass P, Dao LH, *et al.* Risk factors for chronic disease among rural Vietnamese adults and the association of these factors with sociodemographic variables: findings from the WHO STEPS survey in rural Vietnam, 2005. Preventing chronic disease. 2007; 4: A22.
26. Wang W, Lee ET, Fabsitz RR, et al. A longitudinal study of hypertension risk factors and their relation to cardiovascular disease: the Strong Heart Study. Hypertension. Mar 2006; 47: 403-9.
27. Berlin JA, Colditz GA. A meta-analysis of physical activity in the prevention of coronary heart disease. American journal of epidemiology. 1990; 132: 612-28.
28. Tomioka K, Iwamoto J, Saeki K, *et al.* Reliability and validity of the International Physical Activity Questionnaire (IPAQ) in elderly adults: the Fujiwara-kyo Study. Journal of epidemiology / Japan Epidemiological Association. 2011; 21: 459-65.
29. Sobngwi E, Mbanya JC, Unwin NC, *et al.* Physical activity and its relationship with obesity, hypertension and diabetes in urban and rural Cameroon. International journal of obesity and related metabolic disorders : journal of the International Association for the Study of Obesity. 2002; 26: 1009-16.
30. Elley CR, Arroll B. Review: Aerobic exercise reduces systolic and diastolic blood pressure in adults. ACP Journal Club. 2002; 137: 109.
31. Binder S, Navratil K, Halek J. Chronic smoking and its effect on arterial stiffness. Biomedical papers of the Medical Faculty of the University Palacky, Olomouc, Czechoslovakia. 2008; 152: 299-302.
32. Niskanen L, Laaksonen DE, Nyyssonen K, *et al.* Inflammation, abdominal obesity, and smoking as predictors of hypertension. Hypertension. 2004; 44: 859-65.
33. Dochi M, Sakata K, Oishi M, *et al.* Smoking as an independent risk factor for hypertension: a 14-year longitudinal study in male Japanese workers. The Tohoku journal of experimental medicine. 2009; 217: 37-43.
34. Halimi J-Mab, Giraudeau Ba, Vol Sc, *et al.* The risk of hypertension in men: direct and indirect effects of chronic smoking. Journal of Hypertension. 2002; 20: 187-193.
35. Kearney PM, Whelton M, Reynolds K, *et al.* Global burden of hypertension: analysis of worldwide data. Lancet. 2005; 365: 217-23.
36. Kearney PM, Whelton M, Reynolds K, et al. Worldwide prevalence of hypertension: a systematic review. J Hypertens. 2004; 22: 11-9.
37. Doyle ME, Glass KA. Sodium Reduction and Its Effect on Food Safety, Food Quality, and Human Health. Comprehensive Reviews in Food Science and Food Safety. 2010; 9: 44-56.