**Lifestyle and self-management determinants of hypertension control in a sample of
Australian adults**

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Abstract

Background: Poor hypertension control can increase the risk of cardiovascular, renal and kidney diseases, and increase the social and economic burden of the disease. This study aimed to explore the lifestyle and self-management skills (medication adherence, self-monitoring, self-efficacy) determinants of hypertension control in a sample of hypertensive Australians. *Research design and method:* In a cross-sectional design, a total of 233 hypertensive adults completed a survey. Hypertension control was categorised as good control if hypertensive individuals managed to reduce their blood pressure (BP) < 140/90 mmHg, otherwise it was categorised as poor control. Data were analysed using bivariate analysis and hierarchical logistic regression. *Results:* 55% of the participants had poor BP control. A significantly higher frequency of poor BP self-monitoring was observed in individuals with poor control compared to their counterparts. Poor self-monitoring and a sedentary lifestyle were associated with higher odds of poor control (OR: 5.33, 95% CI: 1.78 – 15.93; $p < 0.01$, and OR: 4.69, 95% CI: 1.00 – 22.25; $p < 0.05$, respectively). No significant association was observed between other variables and hypertension control. *Conclusions:* Successful BP control for hypertensive individuals may require interventions and strategies that assist with improving BP self-monitoring skills and increasing physical activity.

Keywords: Hypertension; Blood pressure control; Lifestyle; Self-management; Self-monitoring

1. Introduction

The world has an ageing population, partially due to reduced mortality and increased infertility [1]. Yet, while people live longer, ageing can increase the prevalence of chronic disease and bring burden to society, the economy and the health system [1, 2]. The increased need for health care associated with these changes has shifted the health system from considering patients as the passive recipients of care, to actively engaging patients in treating and managing their conditions [3]. However, the success of patients self-management depends on their day-to-day ability to follow lifestyle changes and symptom management strategies provided by health professionals [3]. Successful self-management can result in effective control of the chronic condition [4].

Hypertension (HTN) (characterised by continuous BP $\geq 140/90$ mmHg) is a major chronic condition affecting over 3.1 million people in Australia [5]. In 2011/12, 68% of all Australian adults with HTN did not effectively control their condition [6]. Uncontrolled BP can lead to cardiovascular disease (CVD), renal and kidney failure and increase the social and economic burden of disease [7]. Patients with newly diagnosed hypertension are advised to modify their lifestyle and diet [7]. Individuals with HTN are advised to follow a healthier diet (low in salt, SFA and high in fruit and vegetables), increase their levels of physical activity, reduce alcohol intake and stop smoking [8, 9]. However, adherence to diet and lifestyle modifications is challenging [10, 11]. Good knowledge of appropriate diet and lifestyle choices may increase an individual's confidence to follow a healthy lifestyle [12]. In addition to lifestyle modification, most individuals with HTN need AHT to control their BP [7]. However, adherence to AHT is also quite poor and depends on an individual's confidence and motivation to follow the required treatment [13].

In recent years, there has been increasing interest in the importance of self-management skills for treating and controlling HTN [14]. Based on the Individual and Family Self-Management Theory (IFSMT), self-management is fundamental to behavioural change and chronic disease control [15]. In this theory, behavioural change self-efficacy, the ability to self-monitor a condition and its fluctuations, and the adherence to treatment determine the success of self-management [16]. In addition, based on the *context* dimension of IFSMT, individuals' physical and mental wellbeing or HRQoL [17] can influence their confidence to change their behaviour [18, 19]. Successful diet and lifestyle modifications may lead to an improvement in health-related quality of life (HRQoL) [20, 21]. Based on the IFSMT *outcome* dimension, a successful lifestyle modification can also improve behavioural change self-management and self-efficacy [15, 19, 22]. Finally, based on the Knowledge-Attitude-Behaviour (KAB) approach, individuals with a better understanding of dietary factors and their relationship with HTN are more likely to follow a healthy diet and manage their condition effectively [23, 24].

Therefore, the conceptual framework of this study is designed based on the IFSMT theory and is presented in Figure 1. Based on this framework, this study hypothesised that a) there is a difference in nutrition knowledge, dietary patterns, lifestyle, HRQoL and self-management skills of individuals with HTN that have good and poor BP control, and b) these variables are associated with poor BP control in a sample of Australian adults with high BP.

Understanding the determinants of poor BP control in individuals with HTN is essential for developing interventions and approaches that aim to improve HTN control among Australian adults.

2. Patients and Methods

2.1 Design and data collection

The design and data collection process of this study is described in details elsewhere [25, 26]. Briefly, a clinical- and community-based cross-sectional study collected data between August and December 2014 using a convenience method of sampling. The Clinical unit of sampling was the Medical Assessment Unit of the Gold Coast University Hospital, and the Community units were the Gold Coast City Council Active and Healthy Classes; and Griffith University. The residents of the City of Gold Coast, Australia were also invited to participate, and were included in the Community unit of sampling. Adults (≥ 18 years of age) with high BP were included in this study. High BP or HTN was defined as SBP ≥ 140 mmHg and/or DBP ≥ 90 mmHg, or medically diagnosed with high BP. In cases where no record of an individual's BP was available, the researcher measured BP in duplicate readings using a validated BP monitor (method explained elsewhere [25]). Those unable to consent to the study, or individuals with severe mental or neurological impairment, or with secondary HTN (due to other causes such as kidney or endocrine problems) were excluded from the study. Ethics approvals were obtained from the Gold Coast University Hospital, and Griffith University ethical committees (HREC Reference Number: HREC/14/QGC/115).

A survey that included information on food frequency, nutrition knowledge, HRQoL, lifestyle, AHT adherence, self-monitoring skills, as well as sociodemographic and anthropometric variables was used to collect data. The food frequency questionnaire (FFQ) developed in Blue Mountains Eye Study [27] was modified and validated for this study and detailed elsewhere [28]. A total of 39 commonly consumed food items, in addition to questions on added salt, oil, and sugar during cooking or serving foods were selected for the modified FFQ. The questionnaire was validated against 3-day food records and had a good

internal consistency (Cronbach's $\alpha = 0.66$), with a good Bland-Altman relative agreement [28]. Factor analysis with Varimax rotation was firstly used to identify survey structure, and subsequent cluster analysis was used to identify dietary patterns. The detailed explanation of the procedure and analysis is presented elsewhere [25]. Three patterns of Western, Snack & Alcohol, and Balanced were derived using cluster analysis. The Western pattern was high in sodium and SFA and loaded with fast-food, processed foods and alcohol. Snack and alcohol pattern was also high in sodium and loaded with chips, crisps, fries, biscuits and alcohol, and the Balanced pattern was a moderate combination of all food groups [25].

The nutrition knowledge questionnaire used in this study was a modified version of the one developed by Hendrie et al. [29] with 26 questions on the dietary recommendation, source of food and nutrients, everyday food choices, and diet-disease relationship. A moderate internal consistency with $\alpha = 0.54$ was observed in this newly modified questionnaire. HRQoL was examined by the Short Form 12 (SF-12, V2) [30] with an acceptable internal consistency ($\alpha = 0.66$). Physical activity, smoking, over-drinking and stress were examined using short questions. The self-efficacy of diet and exercise behaviour changes were assessed using the shortened versions from the one developed by Sallis et al. [31]. The internal consistency of self-efficacy questionnaires was good with alpha levels of 0.76 and 0.89, for self-efficacy of diet (with 8 questions) and self-efficacy of exercise (with 4 question), respectively. A four-item questionnaire developed for this study and described before [26] was used for assessing AHT adherence. Answers were scored on a 3-point scale. Scores 0-2 were considered 'poor adherence', and score 3 was coded as 'good adherence'.

Self-monitoring BP was measured using a 4-item questionnaire, which included statements on: having a BP monitor at home; the frequency of BP measuring; and the individual's feeling of their ability to control BP (2 questions). To score BP self-monitoring, one point was given to having a BP monitor at home and measuring BP at least once a week. Those

who felt good about the BP control received another point. Those who believed they were able to control their BP with the guidance from their health professional received another point. No point was given to the remaining options. BP self-monitoring was categorised as good (score 4) and poor (score 0-3). The BP self-monitoring questionnaire had an acceptable internal consistency with $\alpha = 0.66$ [32]. Blood pressure control was defined as a good control if individuals had controlled their BP (SBP < 140 mmHg and DBP < 90 mmHg). Blood pressure control was checked against the average of BP readings and was confirmed with individuals and the medical professional team (if applicable).

2.2 Statistical analysis

The process of data cleaning and management is described elsewhere [25]. The bivariate analyses of variables were conducted using chi-square for categorical variables and independent t-tests for normally distributed outcome variables, or Mann-Whitney U tests for non-normally distributed outcome variables.

Based on the conceptual framework (Figure 1) and the IFSMT theory, the association between dietary patterns, nutrition knowledge, lifestyle, HRQoL and BP self-management skills with BP control was explored using a hierarchical regression analysis [33]. Four models were identified. In model 1, the association of nutrition knowledge alone and poor BP control was explored. In model 2, the association of dietary patterns and lifestyle variables (physical activity, alcohol overconsumption and smoking) in addition to nutrition knowledge with poor BP control was investigated. In model 3, HRQoL was added to the regression model and its association with poor BP control was assessed. In model 4 the self-management skills (self-monitoring, AHT adherence, self-efficacy of diet and exercise) variables were added to nutrition knowledge, dietary pattern, lifestyle and HRQoL and their association with poor BP

control were assessed. All models were controlled for the confounding influence of significant bivariate sociodemographic variables and sampling units. The stress frequency variable was not included in the regression analysis as it had a significant correlation with the HRQoL total mental domain (0.37, $p < 0.01$). P-value < 0.05 was considered as a statistically significant level.

The sample size was calculated based on previous work by Bramley, Nightengale [34], where 43% of individuals with good AHT adherence successfully achieved BP control compared to 32% in low adherence individuals. Therefore, using GPower software version 3.0 (Heinrich Heine Universitat, Dusseldorf, Germany), with 80% power and $\alpha=0.05$, a sample size of 177 was required to examine associations in this study. Including an additional 20% for non-completed or missing survey responses, a sample size of 213 was considered adequate.

3. Results

A total of 233 hypertensive adults were included. More than half (55%) of these individuals had poor BP control. Of these 224 reported currently taking AHT medication to control BP. Table 1 presents the characteristics of included participants allocated to the poor and good BP control groups. The cross-tabulation analysis of sociodemographic factors shows a significant ethnicity difference between poor and good BP control, with more Caucasians in the good control compared to the poor control group. However, a small group of individuals were included in the group of other ethnicities with good control, which may have influenced the overall results. A significantly higher proportion of individuals with health and nutrition-related qualifications was observed among adults with poor BP control compared to those with good control. No significant differences were observed among other variables.

Table 2 presents differences between the poor and good BP control groups in terms of AHT types and numbers, their comorbidities and sampling units. A significant difference was observed with the sampling units, with the majority of individuals in the good BP control group being from the Clinical sampling unit.

Table 3 presents differences between the poor and good BP control groups with respect to nutrition knowledge, dietary patterns, HRQoL, self-efficacy, lifestyle, BP self-monitoring and AHT adherence. A significant difference was observed in BP self-monitoring between groups with good and poor BP control. Only 9% of individuals with poor BP control had good BP self-monitoring, however, a higher proportion (22%) of those with good BP self-monitoring had good BP control. No significant differences were observed in nutrition knowledge, dietary patterns and HRQoL between the good and poor BP control groups.

The association between nutrition knowledge, dietary patterns, lifestyle factors, HRQoL, BP self-management skills and poor BP control is presented in Table 4. Except for model 1, all models had good fit based on the Hosmer-Lemeshow test. In model 1, nutrition knowledge alone was not a significant determinant of BP control while controlling for confounding variables of ethnicity, health-related qualifications and sampling units. Dietary patterns and lifestyle variables (physical activity, smoking, alcohol overconsumption) were added to model 2. A higher likelihood of having poor BP control was observed when paired with a sedentary lifestyle compared to a rigorously active lifestyle. A similar pattern was detected when HRQoL total physical and total mental domains were added to model 3. In model 4, self-management skills (self-monitoring, AHT adherence and self-efficacy) were included. Poor BP self-monitoring increased the odds of poor BP control more than 5 times. In this model, sedentary lifestyle also increased the likelihood of poor BP control by more than 4.5 times. All models were controlled for ethnicity, health-related qualification and sampling

units. Being Caucasian reduced the odds of poor BP control in all models. No confounding influence of health-related qualification or sampling units was observed on the association.

4. Discussion

In the present study, over half of the study sample did not have their BP under good control. Similar rates of poor BP control among individuals with HTN has also been identified in the US population [35]. Findings from the present study suggest that individuals with poor BP control have lower self-management skills than individuals with good BP control. Based on IFSMT theory [15], success with BP control at the individual level is largely related to an individual's self-management skills and their involvement in the treatment and control of their condition [2, 3]. Hypertensive individuals, especially in the early stages, usually do not experience physical symptoms, therefore, may not feel the need to adhere to treatment or control of their condition [36]. However, regular BP self-monitoring may increase awareness of the condition, the need for action and an individual's active involvement in treatment [37]. Based on IFSMT, self-involvement in the treatment of a condition is a pivotal step in self-managing and controlling that condition [15]. The associations observed in this study support the importance of BP self-monitoring for the control of HTN. In addition, the results show that good control of BP was more common in individuals from the clinical setting. This may be due to frequent BP monitoring that occurs in clinical settings and constant updating of treatment plans to improve the control of HTN and other comorbidities. However, regression analysis in this study did not suggest a significant confounding influence of the setting on HTN control. Also, results indicated that good BP control was more common in individuals with no health-related qualifications. This finding may have been influenced by the low number of participants with health-related qualification included in this study. Although the

confounding influence of health-related qualifications on regression models of BP control was not significant, further investigation is required to explore potential reasons for differences observed.

The findings of this study also reported lower involvement in physical activity for individuals with poor BP control compared to those with good BP control. As designated in the outcome dimension of IFSMT theory, an individual's motivation to change and to self-manage their condition is very much influenced by having successful lifestyle modification outcomes [15]. Therefore, having an inactive lifestyle may limit the success of BP self-management, and reduce the likelihood of BP control. This was further supported by the findings of the present study where associations between physical inactivity and lower likelihood of BP control was observed. Sedentary lifestyles have long been considered a major culprit in many chronic diseases, including HTN, obesity and diabetes [10]. The importance of physical activity to reduce BP has been well investigated in epidemiological and experimental studies [38, 39, 40]. A number of mechanisms have been proposed for this effect. Reducing the circulating catecholamines in serum, decreasing plasma noradrenaline levels and renin activity, and reducing the peripheral vascular resistance are among these [38, 39].

In the present study, no differences in nutrition knowledge, dietary patterns, HRQoL, smoking, overconsumption of alcohol or adherence to medication between groups with poor or good BP control was observed. Although the conceptual framework of this study suggested that these variables may increase the likelihood of BP self-management and control, the findings of this study did not report such associations. Nevertheless, the importance of diet and lifestyle modifications in targeting HTN treatment and control is undeniable [7]. There is compelling evidence suggesting diet plays a critical role in the prevention or onset of HTN [7, 41]. There is no doubt that Western dietary patterns high in salt (sodium), SFA, alcohol and low in fruit and vegetables increases the risk of HTN [7, 41].

Individuals are more likely to choose healthier foods when they have better knowledge of dietary factors [42]. There is also overwhelming evidence for the association between smoking and adverse cardiovascular outcomes [11, 43]. Heavy alcohol consumption has also been associated with higher BP in previous reports [44, 45]. Although these associations were not observed in the current study, it is possible that a combination of these factors, along with other behavioural factors (such as belief, accessibility and availability of food and resources), may be associated with HTN control, since it is a multifactorial condition [7].

To the best of our knowledge, the current study is one of few to have explored associations between nutrition knowledge, dietary patterns, lifestyle factors, HRQoL, BP self-management skills and BP control in Australian adults with HTN. Overall, the study suggests that a sedentary lifestyle and poor BP self-monitoring can reduce the likelihood of successful BP control.

While the findings of this study have valuable public health and clinical implications, there are several limitations that should be noted. The small population sample of the study makes the generalisation of findings difficult. However, participants from both Clinical and Community units were included in the study to increase the generalisation of the results. Also, to partial out the sampling unit differences, this study controlled the confounding influence of sampling units in the analyses. Another limitation of this study is that the majority of the population were Caucasians, which limited the comparison and generalisation of results to other ethnicities. In addition, data collection in this study was conducted using a short self-administered questionnaire, which can introduce reporting bias [46]. For the same reason, some missing and incomplete information (i.e. AHT medication type and name and comorbidities) existed that limited the analysis and interpretation of results. With regards to alcohol consumption, only overconsumption of alcohol (> 2 standard drinks per day for men, or > 1 standard drink per day for women, or > 4 standard drinks in a single drinking occasion)

was included in this study. Therefore, participants were not able to report actual levels of alcohol consumed. In addition, the smoking frequency question was not able to identify the exact number of cigarettes smoked each day or the number of years an individual had been smoking for. Also, the length of diagnosis may influence the success of BP control. However, accurate diagnosis duration recall from individuals with a long history of diagnosis was limited. Due to the limited access this study had to the recorded medical history, especially from individuals in the Community sampling unit, this information was not included. Finally, BP control was defined and classified based on average BP readings and confirmed with medical professionals. However, BP readings are volatile can fluctuate for a number of reasons including the state of other comorbidities, stress and day-to-day variations. Thus, it is important to consider this when interpreting the findings. Future intervention based studies focusing on a cause-effect relationship between these variables and BP control are required to confirm the findings of this study.

5. Conclusion

Overall, the findings of this study emphasise the importance of BP self-monitoring and physical activity in BP control for adults with HTN. Accordingly, hypertensive individuals with poor BP self-monitoring and those following a sedentary lifestyle have lower likelihood of achieving successful BP control. These findings may provide a strategic direction for clinical and public health interventions focusing on HTN control. Educating hypertensive adults to enhance BP self-measurement skills, implementing policies for greater accessibility and affordability of BP monitoring devices, improving knowledge of BP control and increasing individuals' self-control confidence may lead to better BP self-management skills, thus, better BP control. This, along with strategies to improve diet and lifestyle, may

effectively improve rates of BP control among hypertensive individuals, reduce treatment costs and both the clinical and financial burden associated with the disease.

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Key issues:

- Poor hypertension control is common in hypertensive patients which can lead to the development of cardiovascular disease and renal and kidney problems.
- Lifestyle changes and self-management (i.e. self-efficacy, medication adherence, self-monitoring) are proposed as means to improve hypertension management and control.
- This study suggests poor blood pressure self-monitoring and sedentary lifestyle can be significant determinants of poor hypertension control.
- Improving hypertensive patient's self-monitoring skills and physical activity may be effective approaches to improve hypertension control.
- Future interventional studies need to confirm these findings.

1 **Table 1** Characteristics of included participants in good and poor BP control

	Poor control, n (%) (n=130)	Good control, n (%) (n=103)	χ^2 (p-value)
Number	130 (55)	103 (45)	
Age (years of age)			1.08 (0.29)
< 65	77 (59)	54 (52)	
$\geq$ 65	53 (41)	49 (48)	
Gender			1.21 (0.27)
Male	50 (38.5)	47 (46.0)	
Female	80 (61.5)	56 (54.0)	
Ethnicity			6.87 (0.00)
Caucasian	114 (89.0)	98 (98.0)	
Other	14 (11.0)	2 (2.0)	
Marital status			0.34 (0.84)
Married, de facto	82 (63.0)	67 (66.0)	
Divorced, widowed, separated	38 (29.0)	29 (28.0)	
Never been married	10 (8.0)	6 (6.0)	
Education			0.28 (0.86)
Elementary, high school	65 (50.0)	55 (53.5)	
College/ University degree	48 (37.0)	36 (35.0)	
Postgraduate master or PhD	17 (13.0)	12 (12.0)	
Income			2.38 (0.30)
Less than 20k	69 (53.0)	63 (62.5)	
20- < 60k	36 (28.0)	20 (20.0)	
$\geq$ 60k	25 (19.0)	18 (18.0)	

Employment			2.46 (0.48)
Full-time	37 (28.5)	23 (22.5)	
Part-time	21 (16.0)	13 (13.0)	
Unemployed or student	15 (11.5)	11 (11.0)	
Retired	57 (44.0)	55 (54.0)	
Number of people in household			3.30 (0.19)
Single person	24 (19.0)	25 (25.0)	
Medium size (2-4 people)	89 (71.0)	72 (71.0)	
Large size (≥ 5 people)	12 (10.0)	4 (4.0)	
Health-related qualification			4.60 (0.03)
Yes	35 (27.5)	16 (16.0)	
No	92 (72.5)	88 (84.0)	
BMI (kg/m ²)	28.73 (6.30)	29.14 (6.01)	-0.41 (0.64)

2 * BP is presented as mean (SD). The rest of variables are presented as frequency (%). Chi-
3 square was used to compare bivariate differences.

4 **Table 2** Medication types, comorbidities and sampling unit differences among participants
5 with good and poor BP control

	Poor control, n (%) (n=130)	Good control, n (%) (n=103)	χ^2 (p-value)
Types of AHT			1.21 (0.55)
One type	65 (66)	65 (72)	
Two types	21 (21)	18 (20)	
> Two types	12 (13)	7 (8)	
Common AHT			
ACE inhibitors	13 (15)	12 (15)	0.04 (0.99)
Diuretics	15 (18)	15 (18)	
Calcium channel, Beta-blockers or Alpha- receptor blockers	12 (14)	11 (13)	
Others, or did not know	45 (53)	44 (54)	
Comorbidities			6.30 (0.10)
Heart problems	7 (14)	13 (24)	
Obesity	32 (62)	22 (40)	
Diabetes/high cholesterol/or Gout	4 (8)	10 (18)	
Multiple comorbidities	8 (16)	10 (18)	
Sampling Unit			10.62 (0.00)
Clinical	50 (39)	58 (56)	
Community	72 (55)	35 (34)	
Active classes	8 (6)	10 (10)	

7 **Table 3** Difference in dietary pattern, nutrition knowledge, HRQoL, lifestyle and self-monitoring skills, between groups with good and poor BP
8 control

	Poor control, n (%) (n=130)	Good control, n (%) (n=103)	t or χ^2 (p-value)
Nutrition knowledge score (out of 100)	65.90 (13.71)	64.00 (13.60)	1.10 (0.27)
Dietary Pattern			2.31 (0.31)
Western	54 (42.0)	35 (33.5)	
Snack & Alcohol	49 (37.5)	40 (39.0)	
Balanced	27 (20.5)	28 (27.5)	
HRQoL			
Physical function	65.70 (35.50)	63.48 (38.16)	0.45 (0.64)
Role physical	66.47 (30.89)	61.76 (34.59)	1.09 (0.27)
Bodily pain	35.66 (32.74)	44.12 (38.08)	-1.78 (0.07)
General health	54.07 (24.95)	48.53 (26.05)	1.64 (0.10)
Total Physical	55.47 (15.53)	54.47 (18.90)	0.44 (0.66)
Vitality	47.09 (21.79)	48.77 (24.97)	-0.54 (0.58)

Social function	70.16 (30.47)	69.85 (29.08)	0.07 (0.93)
Role emotional	74.42 (25.13)	72.92 (29.17)	0.42 (0.67)
Mental health	57.95 (13.79)	59.19 (18.52)	-0.58 (0.56)
Total Mental	62.40 (14.12)	62.68 (15.36)	-0.14 (0.88)
Lifestyle variables			
Physical activity (hour/week)			
Vigorous	1.90 (3.85)	2.68 (4.60)	-1.33 (0.18)
Moderate	6.60 (7.49)	8.22 (8.88)	-1.47 (0.14)
Light	21.90 (21.10)	19.46 (20.59)	0.87 (0.38)
Sitting activity	29.16 (19.15)	29.02 (18.07)	0.05 (0.95)
Sleeping	47.42 (15.69)	48.07 (16.80)	-0.29 (0.77)
Physical activity categories ¹			
Sedentary	45 (36.0)	26 (26.0)	3.01 (0.22)
Moderate	69 (54.5)	61 (60.0)	
Rigorous	12 (9.5)	14 (14.0)	
Smoking, n (%)			

No	78 (64.5)	62 (61.5)	1.90 (0.38)
Used to	30 (25.0)	32 (31.5)	
Yes	13 (10.5)	7 (5.0)	
Over drinking, n (%)			
Never	56 (46.0)	47 (47.0)	3.28 (0.35)
Often	13 (11.0)	11 (11.0)	
Sometimes	34 (27.5)	34 (34.0)	
Used to	19 (15.5)	8 (8.0)	
Stress, n (%)			
Never	17 (14.0)	17 (16.0)	1.72 (0.63)
Often	27 (22.0)	26 (26.0)	
Sometimes	45 (37.0)	29 (29.0)	
Occasionally	33 (27.0)	28 (28.0)	
Self-management Skills			
BP self-monitoring			
Poor	118 (91)	81 (78.5)	6.13 (0.01)

Good	12 (9)	22 (21.5)	
Self-efficacy			
Diet (out of 100)	70.91 (17.69)	72.92 (18.12)	-0.82 (0.40)
Exercise (out of 100)	63.62 (23.80)	67.72 (20.34)	-1.25 (0.21)
AHT adherence			
Poor	53 (52)	42 (44)	1.04 (0.30)
Good	50 (48)	53 (56)	

- 9 [†] Moderate: physical activities for at least 30 minutes, 5 times per week, which does not cause heavy breathing (e.g. walking, hiking, gardening); Rigorous:
- 10 physical activities for at least 20 minutes, 3 time per week, which cause sweating and heavy breathing (e.g. running, football, shovelling).
- 11 Data presented as mean (SD) or frequency (%). Independent sample t-test and chi-squared test are used were appropriate. Significant p-value level is < 0.05.
- 12 Abbreviations: AHT: anti-hypertensive medication; HRQoL: health-related quality of life

13 **Table 4** The association between nutrition knowledge, dietary pattern, Lifestyle, HRQoL, BP self-management skills, with poor BP control

	Model 1	Model 2	Model 3	Model 4
Poor BP control	Odds ratio (CI)	Odds ratio (CI)	Odds ratio (CI)	Odds ratio (CI)
Knowledge of nutrition	0.99 (0.97-1.02)	1.01 (0.98-1.04)	1.01 (0.98-1.04)	1.01 (0.97-1.05)
Dietary pattern				
Western (vs Balance)	–	1.37 (0.61-3.07)	1.43 (0.63-3.22)	0.81 (0.29-2.24)
Snack & Alcohol (vs Balance)	–	1.26 (0.58-2.71)	1.23 (0.57-2.67)	0.73 (0.28-1.91)
Lifestyle variables				
Physical activity categories				
Sedentary (vs Rigorous)	–	3.15 (1.10-9.03)*	3.12 (1.04-9.30)*	4.69 (1.00-22.25)*
Moderate (vs Rigorous)	–	1.55 (0.57-4.16)	1.58 (0.58-4.25)	2.43 (0.64-9.27)
Smoking, n (%)				
Used to (vs No)	–	2.19 (0.64-7.50)	2.03 (0.58-7.08)	4.15 (0.75-22.83)
Yes (vs No)	–	0.89 (0.45-1.76)	0.87 (0.43-1.72)	0.64 (0.26-1.58)
Over drinking, n (%)				
Often (vs Never)	–	0.77 (0.28-2.08)	0.84 (0.29-2.37)	0.42 (0.09-2.02)

Sometimes (vs Never)	–	0.97 (0.48-1.92)	0.98 (0.49-1.95)	0.90 (0.38-2.11)
Used to (vs Never)	–	2.27 (0.79-6.49)	2.25 (0.77-6.53)	2.60 (0.73-9.21)
HRQoL				
Total physical	–	–	1.00 (0.98-1.02)	0.98 (0.96-1.01)
Total mental	–	–	0.99 (0.97-1.02)	1.00 (0.97-1.03)
Self-management skills				
BP self-monitoring, Poor (vs Good)	–	–	–	5.33 (1.78-15.93)**
AHT adherence, Poor (vs Good)	–	–	–	0.80 (0.35-1.81)
Self-efficacy				
Diet	–	–	–	0.98 (0.95-1.00)
Exercise	–	–	–	1.00 (0.98-1.03)
Ethnicity, Caucasian (vs Others)	0.15 (0.97-1.02)*	0.16 (0.29-0.81)*	0.17 (0.03-0.86)*	0.09 (0.10-0.93)*
Health-related qualification, No (vs Yes)	0.78 (0.38-1.55)	0.63 (0.29-1.37)	0.59 (0.26-1.30)	1.00 (0.38-2.61)
Sampling unit				
Clinical (vs Active classes)	1.23 (0.42-3.61)	1.34 (0.40-4.49)	1.28 (0.38-4.36)	2.27 (0.50-10.21)
Community (vs Active classes)	2.42 (0.84-6.93)	2.13 (0.65-6.97)	2.07 (0.62-6.83)	4.04 (0.91-18.04)

$$R^2 = 0.10^{**}$$

$$R^2 = 0.16^*$$

$$R^2 = 0.16^*$$

$$R^2 = 0.28^{***}$$

14 *p-value < 0.05; ** p-value < 0.01; *** p-value < 0.001. Good fit models, except for model 1. Model 1 (Nutrition knowledge); Model 2 (Nutrition
15 knowledge + Dietary patterns and sleep duration); Model 3 (Nutrition knowledge + Dietary patterns and sleep duration+ HRQoL); Model 4
16 (Nutrition knowledge + Dietary patterns and sleep duration+ HRQoL + Self-efficacy). All models are controlled for sociodemographic variables
17 (age, gender, employment, and income), and sampling units. Abbreviations: HRQoL: health-related quality of life

18 **Figure Caption**

19 **Figure 1.** The conceptual framework of the association between dietary pattern, nutrition
20 knowledge, lifestyle and HRQoL with HTN control