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# Body Mass Index and Risk of Hypertension: 8-Year Prospective Findings From a Nationwide Thai Cohort Study

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Abstract

**Objective:** As Thailand modernizes an ensuing health risk transition associates with rising chronic non-communicable diseases, especially hypertension. This is a driving force for emerging vascular disease, especially stroke and hypertension. Studies in other countries have shown hypertension is associated with obesity. Longitudinal information is needed forthailand and here we present our cohort data collected over 8 years And recording incidence of hypertension and exposure to elevated abnormal BMI.

**Design and Methods:** BMI effects on incident hypertension were investigated prospectively in a nationwide Thai Cohort Study (TCS) from 2005 to 2013. Data were derived from 42 785 off-campus Sukhothai Thammathirat Open University students returning mail-based questionnaire surveys in both 2005 and 2013. Participants analysed were normotensive at the start (40 548). Multivariable regression estimated adjusted relative risks estimate linking obesity (measured by BMI) and hypertension (self-reported) among Thai men and women.

**Results:** In Thailand from 2005 to 2013 the TCS 8-Year Incidence of hypertension was 5.1% (men 7.1%, women 3.6%), which meant 1958 participants developed hypertension. BMI was directly associated with an increased risk of hypertension. Compared to participants with a normal BMI (18.5-22.9 Kg/M2), The relative risks (95% confidence interval) of developing hypertension with a BMI of ≤ 18.5.23.0–24.9, 25-29.9 and >30 Kg/m$^2$ were 0.54 (0.3-0.97), 1.8(1.49-2.18), 3.27 (2.73-3.91) and 6.73 (5.1-8.97) for men and 0.65 (0.45-0.95), 2.28 (1.81-2.88), 3.71 (2.96-4.64) and 9.72 (7.09-13.32) for women respectively (p-trend <0.0001).

**Conclusion:** Our data confirmed the adverse effects of long-term high bmi on an increased risk of hypertension in Thai people. Therefore, Ministry of Public Health should develop a national program to encourage people to remain healthy with a normal BMI. There are many health gains from such a program and the information presented here shows clearly that decreased hypertension would be one of the expected benefits for the Thai population.

**Keywords:** hypertension, socioeconomic status, body mass index, physical activity, underlying diseases, smoking, soft drink, Thailand

## 1. Introduction

Around the world, hypertension is an important chronic non-communicable disease. As well, it is the leading risk factor for other important conditions, especially vascular and kidney disease (Global Burden of Metabolic Risk Factors for Chronic Diseases Collaboration, 2014). More than 1 billion of the world's adult population are estimated to have hypertension in 2000 and the trend indicates this number will grow to 1.6 billion by 2025 (Kearney et al., 2005). Worldwide primary prevention of hypertension is crucial to decreasing associated vascular morbidity and mortality including ischemic heart disease and stroke, two of the leading causes of death (World Health Organization, 2018). The etiology of vascular disease is extensively studied in more developed countries and is attributed to a complex combination of genetics, demographics, nutrition and environment (Shrout, Rudy, & Piascik, 2017). Obesity and physical inactivity are key environmental risk factors for hypertension (Huai et al., 2013; Shihab et al., 2012). Indeed, one of the environmental factors – obesity – is a growing health challenge worldwide and is expected to cause an increase in vascular diseases. Globally the proportion of adults who are overweight (BMI>25 kg/m$^2$) increased from 28.8% in 1980 to 36.9% in 2013 in men and from 29.8% to 38% in women, respectively (Ng et al., 2014).

This worldwide trend in vascular diseases has spread to Thailand, a middle-income country in Southeast Asia with a population profile typical of its region. Thai National Health Examination Surveys in 2004, 2009 and 2014 found the prevalence of hypertension in adults was 22.0%, 21.5%, and 24.7 % respectively, close to but still lower than comparable rates in the USA (29%) and China (26.7%) (Aekplakorn, 2016; Aekplakorn et al., 2008; Aekplakorn et al., 2012; Egan, Zhao, & Axon, 2010; Li et al., 2015). The increased prevalence of hypertension coincided with increased prevalence of obesity (BMI ≥25 kg/m$^2$), in 2004, 2009 and 2014 (34.3%, 40.7% and 41.8% in women and 22.4%, 28.4% and 32.9% in men, respectively) (Aekplakorn, 2016; Aekplakorn & Mo-Suwan, 2009). During this period the average BMI in Thai people continuously increased from 22.8 kg/m$^2$ in women and 21.6 kg/m$^2$ in men in 2009 to 24.6 kg/m$^2$ and 23.6 kg/m$^2$ in 2014 respectively (Aekplakorn, 2016; Aekplakorn et al., 2014). Increased prevalence of hypertension is likely associated with an increased prevalence of obesity and this connection needs more detailed assessment across Thailand and elsewhere (Shihab et al., 2012; Thawornchaisit et al., 2013c, 2018).

In Thailand few studies investigated the association of obesity and hypertension (Thawornchaisit et al., 2013a; Thawornchaisit et al., 2013c, 2018). To fill this gap in our knowledge regarding the overall health risk transition in Thailand we began in 2005 a nationwide Thai Cohort Study (TCS) and followed up every 4 years until 2013. During this time Thailand transformed from a low- to a middle-income country. In 2005, the TCS data revealed the baseline prevalence of hypertension was 4.6% and follow-up at 4 and 8 years showed the cumulative incidence of hypertension over those periods was 3.5% and 5.1%, respectively (Thawornchaisit et al., 2013a; Thawornchaisit et al., 2013c, 2018). We noted in our previous TCS reports that aging, obesity, physical inactivity, and several underlying conditions including diabetes mellitus, high blood lipids and kidney disease are major risk factors of hypertension in Thai people. Here we report a detailed analysis of the link between body mass index and incident hypertension in our large nationwide prospective cohort study of over 42 785 healthy Thais with 8 years of follow-up.

## 2. Methods

### *2.1 Study Population and Data*

The Thai Cohort Study (TCS) began in 2005 when 87151 distance-learning students of Sukhothai Thammathirat Open University (STOU) enrolled in their home environments nationwide. In comparison with the general Thai population, the STOU student body and those students who became TCS members were comparable for social geography and socio-economic status (Seubsman, Yiengprugsawan, Sleigh, & the Thai Cohort Study, 2012). But the Open University student body and study cohort members were younger with 56.2% and 51.5% respectively in the 21–30 year age range compared to 23.9% in the general Thai population, and fewer were older than 50 years (1.2% and 2% respectively) compared with 24.7%. In addition, the STOU student body and TCS members tended to have a higher education level than the general population.

TCS baseline data in 2005 were generated from a 20-page mail-out questionnaire which included questions on demography, socio-economic status (SES), personal health (chronic kidney disease, diabetes mellitus, high blood lipids, high blood pressure, stroke, various cancers, goitre, epilepsy, asthma, arthritis, chronic bronchitis and depression). As well there were questions on hearing, vision, dental impairment, use of health services, transport, injury, social networks, personal well-being, health-related behaviour and family background. Baseline data have been published (Seubsman, Yiengprugsawan, Sleigh et al., 2012; Sleigh, Seubsman, Bain, & Thai Cohort Study, 2008). The number of original cohort members participating in 2009 at 4-year follow up was 60569 (70%) and in 2013 at 8-year follow up was 42785 (49%).

### *2.2 Incident Hypertension*

Hypertension was based on doctor diagnosis detected by self-report. We classified cohort members as cases of incident hypertension if they self-reported as normotensive in 2005 and doctor diagnosed hypertension in 2013. Thus we analysed the 40548 participants in 2005 who were negative for hypertension at the start and who represented 94.8% of the 42785 cohort participants with 8 years of longitudinal data. Hypertension incidence was the binary dependent outcome variable for logistic regression analyses and the person-time denominator included all individuals at risk.

### *2.3 Independent Variables*

The independent variables that were available for analysis included age, sex, marital status, urbanization, socio-economic status (SES - income, household assets, and education), body mass index (BMI), and underlying diseases (diabetes mellitus, high lipids and kidney disease). Other variables we analysed included sedentary habits (screen time, sitting time and house-work or gardening), other lifestyle factors (physical exercise, tobacco smoking, alcohol consumption, soy bean consumption, fruit and vegetable intake and soft drinks) and food preferences (Western, roast, smoked, instant, deep fried).

We categorized age in years (≤ 30. 31-40, >40), marital status as single or married/living with a partner, and urbanization in childhood (aged 12 years) and at study baseline (2005) – 4 lifelong categories: ruralites (RR), urbanizers (RU), de-urbanizers (UR) and urbanites (UU). Three categories coded education level (High school, Diploma, University), four categories coded income in baht (42 baht equalled one US dollar in 2005) and three categories coded household assets (low, medium, high). International Obesity Task Force BMI cut-off guidelines for Asia (Kanazawa et al., 2005) were used -- underweight (BMI < 18.5), normal (18.5 ≤ BMI < 23.0), overweight (23 ≤ BMI < 25.00), or obese I (25 ≤ BMI <30.00), obese II (BMI ≥ 30).

Sedentariness was measured as sitting time and screen time (hours/day). Incidental exercise (housework or gardening frequency), was categorised into 4 groups: ≤3 times per month; 1-2 times per week; 3-4 times per week; most days. Various forms of physical activity (at least 20 minutes of mild, moderate or strenuous exercise, 10 minutes or more walking sessions) were also included and recorded using 4-item ordinal categories.

At both the baseline and the 8-year mark, we calculated separate overall measures of planned physical activity. This was based on the cohort members reporting the number of sessions per week of strenuous and moderate exercise for at least 20 minutes, and of walking for at least 10 minutes. We weighted the measure as follows: (2×strenuous+1×moderate+1×walking) sessions per week, weighting based on the recommendation of the International Physical Activity Questionnaire and the Active Australia Survey as used in other analyses of cohort data (Australian Institute of Health and Welfare, 2003; Banks, Lim, Seubsman, Bain, & Sleigh, 2011). Finally, for each individual, the 'overall measures' of weekly exercise for 2005 and 2013 were added and then averaged by dividing by 2, creating a longitudinal measure of planned physical activity (LPPA).

Self-reported smoking was coded as never, ex-smoker or current smoker. Alcohol consumption was coded as never, ex-drinker, occasional drinker or current-drinker. Foods that may influence hypertension (deep fried, instant, roast or smoked, soybean products and soft drinks) and Western-style fast foods were assessed for consumption frequency. Fruit and vegetable consumption were recorded as standard servings eaten per day.

### *2.4 Statistical Analyses*

All analyses used SPSS software. Hypertension incidence and 95% CI were calculated for each value of each categorical variable. For statistical inference, all p values were two tailed and significance was set at 5%.

We used the longitudinal data to estimate the relative effect of BMI at baseline in 2005 on hypertension incidence detected by 2013, adjusting for the confounding effect of a wide array of variables. In such a large longitudinal study of an uncommon disease (incidence less than 10%) odds ratios (ORs) accurately estimate relative risks (RRs) (Webb & Bain, 2011). Accordingly, we used multivariable logistic regression with the binary 8-year outcome set to incident hypertension, controlling for confounding, so calculating odds ratios that we accepted as relative risk estimates. The explanatory variable of interest was BMI and confounding covariates were age, sex, marital status, socioeconomic status (SES), sedentary habits, physical activities, underlying diseases, personal behaviours (cigarette smoking and alcohol drinking), instant food and soft drink consumption. A co-variable was included in the multivariable model as a confounder if bivariate analysis indicated statistically significant association with incidence of hypertension. Some variables were included because earlier reports elsewhere had shown a significant or substantial association with hypertension.

## 3. Results

### *3.1 Baseline Characteristics*

Overall, 42785 of the original cohort participated in the 8-year follow up. Of these cohort members 40548 had self-reported normotension in 2005 are shown in Table 1. The mean age at baseline of these longitudinal participants was 32 years (33.7 for men and 30.8 for women) and there were more women than men (56%vs 44%). By region, the highest proportion of participants resided in the North-east (men) and Center (women) while the lowest proportion lived in the East (both sexes). Sixty-one and sixty-four percent of the male and female participants respectively lived in urban areas. Fifty and sixty one percent of male and female participants respectively had a higher education attainment than high school. Forty seven percent of male and twenty three percent of female participants had income more than 10000 baht. The distribution of household assets of participants was quite similar with a slightly higher proportion of participants in the low category in both men and women. The majority of men and women had normal weight BMI and the percentage in men and women were 48% and 60 % respectively. Compared to women, men had higher proportions overweight or obese but had lower proportion underweight.

Table 1. Characteristics of 40 548 Thai Cohort Study participants normotensive in 2005 and self-reporting in 2013 by sex

| Factor | Male | | Female | | Difference |
|---|---|---|---|---|---|
| | N | Percent | N | Percent | P Value[a] |
| **Demographic data** | | | | | |
| Participants | 17769 | 43.8 | 22779 | 56.2 | <0.0001 |
| Age (years) mean (SD) | 33.7 | 8.6 | 30.8 | 7.7 | <0.0001 |
| **Age group (year)** | | | | | <0.0001 |
| ≤30 | 7177 | 40.4 | 12505 | 54.9 | |
| 31–40 | 6738 | 37.9 | 7468 | 32.8 | |
| >40 | 3854 | 21.7 | 2806 | 12.3 | |
| **Married/partnered** | | | | | <0.0001 |
| No | 6884 | 39.7 | 12062 | 54.3 | |
| Yes | 10442 | 60.3 | 10144 | 45.7 | |
| **Regions** | | | | | <0.0001 |
| Bangkok | 2393 | 13.6 | 4129 | 18.2 | |
| Central | 3927 | 22.2 | 5703 | 25.2 | |
| North | 3802 | 21.5 | 4323 | 19.1 | |
| North-east | 4395 | 24.9 | 4185 | 18.5 | |
| East | 1017 | 5.8 | 1331 | 5.9 | |
| South | 2119 | 12 | 3003 | 13.2 | |
| **Urbanisation status[b]** | | | | | <0.0001 |
| Rural-rural (RR) | 1319 | 20.9 | 1189 | 17.5 | |
| Rural-urban (RU) | 1786 | 28.3 | 1996 | 29.4 | |
| Urban-rural (UR) | 1131 | 17.9 | 1215 | 17.9 | |
| Urban-urban (UU) | 2069 | 32.8 | 2392 | 35.2 | |
| **Socioeconomic status** | | | | | |
| **Education level** | | | | | <0.0001 |
| High school | 9026 | 50.9 | 8811 | 38.8 | |
| Diploma | 3976 | 22.4 | 6886 | 30.3 | |
| University | 4731 | 26.7 | 7022 | 30.9 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Personal monthly income (baht)** [c] | | | | | | | <0.0001 |
| ≤7000 | | 5286 | 30.2 | | 9377 | 42.1 | |
| 7001-10 000 | | 3940 | 22.5 | | 5274 | 23.7 | |
| 10 001-20 000 | | 5605 | 32 | | 5502 | 13.8 | |
| >20 000 | | 2660 | 15.2 | | 2125 | 9.5 | |
| **Household assets¶ (baht)** [d] | | | | | | | |
| Low | | 6604 | 37.3 | | 8529 | 37.6 | |
| Medium | | 5768 | 32.6 | | 7097 | 31.3 | |
| High | | 5332 | 30.1 | | 7055 | 31.1 | |
| **BMI classification**[e] | | | | | | | <0.0001 |
| Underweight (BMI <18.5) | | 995 | 5.7 | | 4257 | 18.9 | |
| Normal (18.5 ≤ BMI < 23) | 294 | 8439 | 48.2 | | 13476 | 59.8 | |
| Overweight (23 ≤ BMI < 25) | 469 | 4085 | 23.3 | | 2476 | 6.2 | |
| Obese (25 ≤ BMI < 30) | 104 | 469 | 3523 | 20.1 | 1889 | 8.4 | |
| Obese II | | 465 | 2.7 | | 437 | 1.9 | |

[a] $\chi^2$ test for all variables except mean age which was compared by t test.

[b]Location of residence (rural, R, or urban, U) before and in 2005. The values showed only participants who moved their residences within 5 years;

[c]At the time of the survey in 2005, US$1 = 42 Thai baht;

[d]Replacement value in Thai baht, categorized into three groups: low ≤30,000, medium 30,001-60,000 and high >60,000;

diseases, personal behaviours, instant food and soft drink;

[e]Asian standard BMI classification.

### *3.2 Incidence and Risks of Hypertension*

In Thailand, the incidence of self-reported doctor diagnosed hypertension in adults was 5.1% and the rate in men was approximately twice the corresponding rate in women (7.1% vs 3.6%; Table 2). In men and women, incidence of hypertension increased with age, higher BMI, physical inactivity, diabetes mellitus, chronic kidney disease and high lipids. But the risk of hypertension was unaffected by sex, having a partner, urbanization, SES, education level, personal income, household asset, sedentary habits, alcohol drinking, instant food intake and fruit and vegetable consumption (Table 2, some data not shown). Smoking and soft drink consumption were associated with an increased risk of hypertension in men but not in women (data not shown).

In both men and women, higher BMI significantly associated with an increased risk of incident hypertension (Table 2). With normal BMI (18.5-22.9 kg/m$^2$) as the reference, the relative risks (95% confidence intervals) of developing hypertension with a BMI of ≤ 18.5, 23.0–24.9, 25-29.9 and >30 kg/m$^2$ were 0.54 (0.3-0.97), 1.8 (1.49-2.18), 3.27 (2.73-3.91) and 6.73 (5.1-8.97) for men and 0.65 (0.45-0.95), 2.28 (1.81-2.88), 3.71 (2.96-4.64) and 9.72 (7.09-13.32) for women, respectively (P-trend <0.0001).

In both men and women, planned physical activity, averaged across the 8-year follow-up, was a protective factor. The higher LPPA categories (≥8-14 and ≥15 sessions/week) were associated incrementally with lower incidence of hypertension, but the trend is not statistically significant in women.

Table 2. Hypertension incidence and association with age and BMI in male and female participants

| | Male | | | Female | | |
|---|---|---|---|---|---|---|
| | HT (n) | I% [a] (95% CI) | aRR [b] (95% CI) | HT (n) | I% [a] (95% CI) | aRR [b] (95% CI) |
| **Participants** | **1189** | **7.1(6.7-7.5)** | | **769** | **3.6(3.3-3.8)** | |
| **Age group** (year) | | | | | | |
| ≤30 | 208 | 3.0 (2.6-3.4) | 1 | 148 | 1.2 (1.0-1.4) | 1 |
| 31–40 | 444 | 7.0 (6.4-7.6) | 1.76 (1.42-2.18) | 308 | 4.4 (3.9-4.9) | 3.2 (2.5-4.1) |
| >40 | 537 | 15.0 (13.8-16.1) | 3.64 (2.85-4.65) | 313 | 12.0 (10.7-13.2) | 8.28 (6.17-11.11) |
| P-trend | | <0.0001 | <0.0001 | | <0.0001 | <0.0001 |
| Yes | 50 | 12.3 (9.1-15.5) | 1.60 (1.11-2.30) | 33 | 6.3 (4.2-8.4) | 2.0 (1.33-3.04) |
| **BMI classification**[c] | | | | | | |
| Underweight (BMI <18.5) | 14 | 1.5 (0.7-2.3) | 0.54 (0.3-0.97) | 39 | 1.0 (0.6-1.3) | 0.65 (0.45-0.95) |
| Normal (18.5 ≤ BMI < 23) | 289 | 3.6 (3.2-4.0) | 1 | 282 | 2.2 (2.0-2.5) | 1 |
| Overweight (23 ≤ BMI < 25) | 294 | 7.6 (6.8-8.4) | 1.8 (1.49-2.18) | 163 | 7.0 (6.0-8.1) | 2.28 (1.81-2.88) |
| Obese I (25 ≤ BMI < 30) | 469 | 14.1 (12.9-15.2) | 3.27 (2.73-3.91) | 190 | 10.6 (9.2-12.0) | 3.71 (2.96-4.64) |
| Obese II (BMI ≥30) | 104 | 23.5 (19.5-27.4) | 6.73 (5.1-8.97) | 86 | 20.4 (16.6-24.3) | 9.72 (7.09-13.32) |
| P-trend | | <0.0001 | <0.0001 | | <0.0001 | <0.0001 |

[a] Incidence of Hypertension;

[b] Relative risks (estimated as odds ratios - see methods) from multi-variable logistic regression models of hypertension adjusted for age, sex, marital status, socioeconomic status (exclude type of house), BMI classification, sedentary habits, physical activities, underlying diseases, drinking, smoking, instant food and soft drink;

[c] Asian standard BMI classification.

## 4. Discussion

This is the first large nationwide cohort study to analyse the association between obesity and incidence of hypertension in Thai adults. Starting in 2005, participants initially normotensive were followed up until 2013 revealing a cumulative incidence of hypertension over the 8-year period of 5.1%, with the rate in men about twice that in women. In our large, prolonged prospective cohort study, a progressively higher baseline BMI was directly and significantly associated with an increased risk of incidence of hypertension. Our results were comparable with many cross-sectional studies but we will not discuss these here. Our data are longitudinal and therefore should be compared to other more definitive longitudinal studies.

Our TCS data confirmed that in both men and women, compared to the normal BMI, higher BMI in those who were overweight, obese I and obese II showed adverse effects on an increased risk of hypertension. In contrast, lower BMI in underweight participants had protective effects. These findings are consistent with an 11-year Finnish cohort study which reported that overweight and obese men and women has a significantly higher risk of incident hypertension compared to those with normal weight (Hu et al., 2004). Similar findings were also reported from a follow up study spanning 11 years in Norway (Droyvold, Midthjell, Nilsen, & Holmen, 2005). In addition, a study of 13600 American men and women with an average of 8.7 years of follow-up showed that weight gain and obesity were significantly associated with higher risk of hypertension and each unit of BMI elevation was estimated to increase 9% risk of developing hypertension (Rankinen, Church, Rice, Bouchard, & Blair, 2007). Elevated BMI was also associated with a higher blood pressure (Rankinen et al., 2007). However, the risk of hypertension in this US study was not linearly associated throughout the distribution of BMI, and started to emerge when BMI was greater than 27.3 in men and 24.6 in women (Rankinen et al., 2007). In rural China a cohort study included 10145 male and female participants to investigate the association between change in body weight and incident hypertension and found that weight gain substantially increased the risk for hypertension with-a dose-response relationship (Zhang et al., 2017). Another 5-year prospective study of 5370 Chinese participants revealed that in men and women, increased body mass index was significantly associated with an increased risk of incident hypertension while weight loss contributed to the treatment of hypertension (Ren et al., 2016). In Portugal a 3.8 years of population base prospective study demonstrated that overweight and obese had significantly increased risk of hypertension (Pereira et al., 2012). Prospective study of 731014 US army soldiers demonstrated that soldiers who were normal weight at accession and became overweight and obese later had a significantly higher risk of developing hypertension (Hruby et al., 2017). Evidently, research reported in many settings reveals a consistent relationship between overweight or obesity and a substantial risk of hypertension.

Our findings in men was similar to other reports. For example, a 14.5 years prospective study of 13500 American men also showed higher BMI was strongly and positively associated with an increased risk of incident hypertension (Gelber, Gaziano, Manson, Buring, & Sesso, 2007). Also a 25.7-year follow-up study of 1547189 Swedish men revealed that high BMI was a significant risk for developing hypertension (Crump, Sundquist, Winkleby, & Sundquist, 2016). Overweight and obese men had a higher risk of incident hypertension when compared with those with normal weight (Crump et al., 2016). Men with high BMI and low aerobic capacity were associated with highest risk to develop hypertension in adulthood (Crump et al., 2016). In addition, a 27-year follow-up study which included 17059 Japanese men revealed that risk of incident hypertension positively and significantly increased with an increased BMI (Someya et al., 2018). This study suggested that the overweight BMI inflection point for vascular diseases among Japanese men was >23 $kg/m^2$ which was similar to the BMI cut-off used in our study (Someya et al., 2018). In men, BMI is positively associated with risk of incident hypertension.

Our findings in women were consistent with other studies. A 16.7-year prospective study of 5296 normotensive healthy women in the USA showed an association of high baseline BMI with an increased risk of developing hypertension (Shuger, Sui, Church, Meriwether, & Blair, 2008). Also an Australian Longitudinal Study on Women's Health with 14-year follow up 10339 mid-aged women revealed that elevated BMI was associated with an increased risk of incident hypertension (Jackson, Herber-Gast, & Brown, 2014). In addition, the 18-year follow up study of 82473 American female nurses revealed that BMI at 18 years of age and midlife were directly associated with incidence of hypertension with an increase of 1 $kg/m^2$ BMI associated with a 12% increase in risk of hypertension (Huang et al., 1998). Long-term weight loss was significantly associated with lower risk for hypertension while weight gain significantly increased the risk (Huang et al., 1998). In the USA, a prospective study of 46224 females who were participants in the Nurse Health Study II reported that BMI and weight gain were independently associated with the development of hypertension in 46,224 females (Field et al., 1999). In women, elevated BMI is strongly associated with an increased risk of incident hypertension.

In our study, underweight BMI in both men and women had a lower risk of hypertension compared to those with normal BMI, which was consistent with previous studies. The Framingham cohort study demonstrated a lower risk of hypertension in overweight and obese participants who have a long-time reduction of weight (Moore et al., 2005). In addition, a three-year randomized clinical trial showed that long-term weight loss was associated with decreased risk of hypertension starting from 6 months suggesting that weight reduction should be an effective method for primary prevention of risk hypertension (Stevens et al., 2001). A 74-month prospective Northern Italian study of the effect of body weight loss on blood pressure showed that 10% of body weight loss was associated with a decrease of systolic and diastolic blood pressure (mmHg) of 6.2 and 3.6 (Winnicki et al., 2006). Our results also showed body weight reduction was associated with a reduced risk of hypertension.

Our study has some strengths. In Thailand, it is a large nationwide 8-year prospective cohort study designed to permit analysis of obesity and incident hypertension. The study analysed 40 548 participants who were STOU students living in all regions of Thailand, representing Thai people well socio-demographically (Seubsman, Yiengprugsawan, & Sleigh, 2012). A previous 4 and 8 years follow up study in 2009 and 2013 demonstrated all risk factors for hypertension in Thai people but this study focused on association of body mass index and risk of incident hypertension (Thawornchaisit et al., 2013c, 2018). Worldwide there are many studies reporting body mass index and risk of hypertension. However, hypertension has multiple risk factors and differences in genetics, environment, lifestyle and food consumption make it necessary to get information that fits the local population and such data are needed for Thailand.

There are some limitations. This is a self-reported questionnaire study so data may have some error from misreporting. And the study participants are younger and have a higher education attainment than average for general Thai people. However, the validity study on self-reported weight and height in Sukhothai Thammathirat Open University was acceptable (Lim, Seubsman, & Sleigh, 2009). Also we performed a validation study of self-reported hypertension using a random age-sex matched sample of the cohort reporting hypertension (n=240) or no hypertension (n=240) (Thawornchaisit et al., 2013b). We found that the sensitivity was high (82%) and that the negative reports were usually accurate (86%). Also published is our study validating self-reported diabetes (Papier et al., 2017). We also investigated the impact of the non-responses to the 2009 follow-up and found small effects with under-representation of young urban men; this missing group would have a minor influence on our results and would not be expected to have a high rate of incident hypertension (Thinkhamrop, Seubsman, & Sleigh, 2011).

The results from our study represent well the future trends of hypertension in Thai people. Our data confirmed the adverse effects of long-term high BMI on an increased risk of hypertension in Thai people. As noted in many setting lifestyle adjustment including weight reduction, physical activity, and dietary modification are needed to prevent hypertension (Chobanian et al., 2003). Therefore, Ministry of Public Health should develop a national program to encourage people to remain healthy with a normal BMI. There are many health gains from such a program and the information presented here shows clearly that decreased hypertension would be one of the expected benefits for the Thai population.

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**Ethical Considerations**

Ethical approval was obtained from Sukhothai Thammathirat Open University Research and Development Institute (protocol 0522/10) and the Australian National University Human Research Ethics Committee (protocol 2004344 and 2009570). Informed, written consent was obtained from all participants.

**Competing Interests Statement**

The authors declare that there are no competing or potential conflicts of interest.

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