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Effect of body weight changes on hypertension in Indonesian adults (A 14-year follow up)

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Abstract

Background: Obesity is one of the major risk factors of hypertension. There is no large cohort study designed to investigate the quantitative association between body weight changes and the risk of hypertension in Indonesia. The aim of this study was to determine the impact of longitudinal BMI changes on hypertension in Indonesian adults. **Methods**: Body Mass Index (BMI) was computed by dividing weight (kg) by height squared (m^2). Based on the BMI at baseline, the participants formed four weight-change groups: normal weight-maintainers, weight-gainers, weight-losers and overweight or obese-maintainers. The effect of age on the relationship between body weight changes and hypertension was analyzed by logistic regression models using stratified analysis. **Results**: Four body weight changes were identified: *normal weight-maintainers* (41.95%), *weight-gainers* (18.83%), *weight-losers* (5.24%), and *overweight or obese-maintainers* (33.98%). The stratified logistic regression analysis showed that changes in the relationships between the BMI changes and hypertension with age generally tended to be positive in the younger age-based subgroups but negative in the older subgroups. Relative to the *normal weight-maintainers*, the *weight-gainers* had the highest likelihood of hypertension (OR=1.68 95%CI [1.23-1.93]). **Conclusions**: The findings of the study underline the importance of maintaining normal weight for preventing hypertension especially for the middle-aged.

Keywords: body mass index, body weight changes, longitudinal,hypertension

Introduction

Hypertension, also known as high or raised blood pressure, is a condition in which the blood vessels have persistently raised pressure,[1] has been well recognized as a major independent risk factor for cardiovascular disease and stroke.[2] Cardiovascular disease is the major cause of death and disability, both in the developing and the developed regions of the world.[3] Hypertension is one of the most important causes of premature death worldwide. In 2025, an estimated 1.56 billion adults will be living with hypertension.[4] Hypertension kills nearly 8 million people every year, worldwide and nearly 1.5 million people each year in the South-East Asia (SEA) Region.[4] In Indonesia, hypertension is a common condition in primary health care.[5] Based on *Riset Kesehatan Dasar* (RISKESDAS) 2013 showed that the prevalence of hypertension in Indonesia is still high (25.8%). Based on the measurement of blood pressure, hypertension prevalence in the population aged 18 years and over in 2007 in Indonesia is 31.7%. When compared with the year 2013 there was a decrease of 5.9% (from 31.7% to 25.8%). This decline could be due to various factors, such as different preventive measures taken by people who are already aware of the dangers of hypertension.[6]

Obesity is one of the major risk factors of hypertension.[7] According to World Health Organization (2018), overweight and obesity are defined as abnormal or excessive fat accumulation that may impair health. Overweight and obesity were now considered as serious health problems, with an increasing prevalence worldwide.[7] In 2016, 39% of adults aged 18 years and over (39% of men and 40% of women) were overweight. In Indonesia, the prevalence of obese adult male population in 2013 was 19.7%, which is higher than 2007 (13.9%) and 2010 (7.8%). The prevalence of adult female obesity (>18 years) 32.9%, up 18.1% from 2007 (13.9%) and 17.5% from 2010 (15.5 percent).[6]

The relationship of obesity and hypertension has been known since the 20th century, when blood pressure was first measured in the population. Epidemiological data clearly supports the relationship between weight and blood pressure. Increased weight is a major risk factor for increased blood pressure.[8] Anthropometric indices including body mass index (BMI) are used most frequently to define different obesity categories among various populations. General obesity classified by BMI are confirmed to be associated with incident hypertension. Data from NHANES indicated that the prevalence of hypertension in obese individuals (BMI ≥ 30 kg/m^2) was

42.5% versus 27.8% for overweight individuals (BMI 25.0–29.9 kg/m^2) and 15.3% in individuals underweight (BMI < 25 kg/m^2).[8]

While the relationships between obesity and hypertension are well recognized, there is no large cohort study designed to investigate the quantitative association between body weight changes and the risk of hypertension in Indonesia. In addition, there were few studies with powerful samples enough in Indonesia. This study was based on data from the Indonesian Family Life Survey, an ongoing longitudinal survey population-based. This data provides an excellent opportunity to investigate the association between body weight changes and hypertension. The aim of this study was to determine the impact of longitudinal BMI changes on hypertension in Indonesian adult.

Methods

The data source for this study is the Indonesia Family Life Survey (IFLS). IFLS is an ongoing longitudinal survey. The confidentiality and anonymity of the names, addresses, locations and neighbourhoods of the study participants was kept by the data source. Under the RAND human subjects protection rules, respondents participating in the survey were given an assurance that their answers were confidential and that their identity would not be revealed to anyone other than through an anonymous code.

The first wave, IFLS1, was conducted in 1993–1994. The survey sample represented about 83% of the Indonesian population living in 13 of the country's 26 provinces. IFLS-1 collected information from over 22,000 individuals living in 7,224 households. These original households and their split-offs were followed in subsequent waves fielded in 1997/1998, 2000, 2007/2008 and 2014. The recontact rates for the target households were more than 90% in all follow-up surveys. Among the original 33,081 IFLS1 household members, about one-third, 11,040 were found in their original IFLS households during IFLS5. The recontact rate (including deaths) in IFLS5 among IFLS1 individuals is thus 76%.[9] The IFLS data are open for public use after registration on their website (http://www.rand.org/labor/ FLS/IFLS/ifls4.html). At baseline, a total of 11,677 participants ≥40 years were recruited for this study. We excluded participants with hypertension (n = 4,157) at baseline; of missing indicators of BMI at baseline (n = 2,218), underweight defined by BMI < 18.5 kg/m^2 (n = 1,158) at baseline. We excluded data for participants who were became underweight during follow-up (n = 225) because of the possibility of any medical conditions that would affect BP. Thus, the final study sample was 2,560 (Figure 1). Baseline physical examinations were conducted in IFLS Wave 3 (2000). The participants completed a physical examination, including height, weight, and blood pressure measurements.

A questionnaire was administrated a personal interview to determine health-related risk factors and obtain personal information, including detailed socio-demographic characteristics. Three BP measurements were obtained using Omron self-inflating sphygmomanometers with a digital read-out. Hypertensive status was ascertained based on self-report and the mean BP value of three measurements. Respondents were classified as hypertensive if they had any of these conditions: (1) average systolic blood pressure ≥140 mmHg; (2) average diastolic blood pressure ≥90 mmHg; (3) being known case of hypertension (diagnosed by a physician) or receiving medications for hypertension. Obesity as an independent variable was measured by using Body Mass Index (BMI) was computed by dividing weight (kg) by height squared (m^2). This study applied the World Health Organization (WHO) classification for adult Asians to categorize BMI values into the following BMI

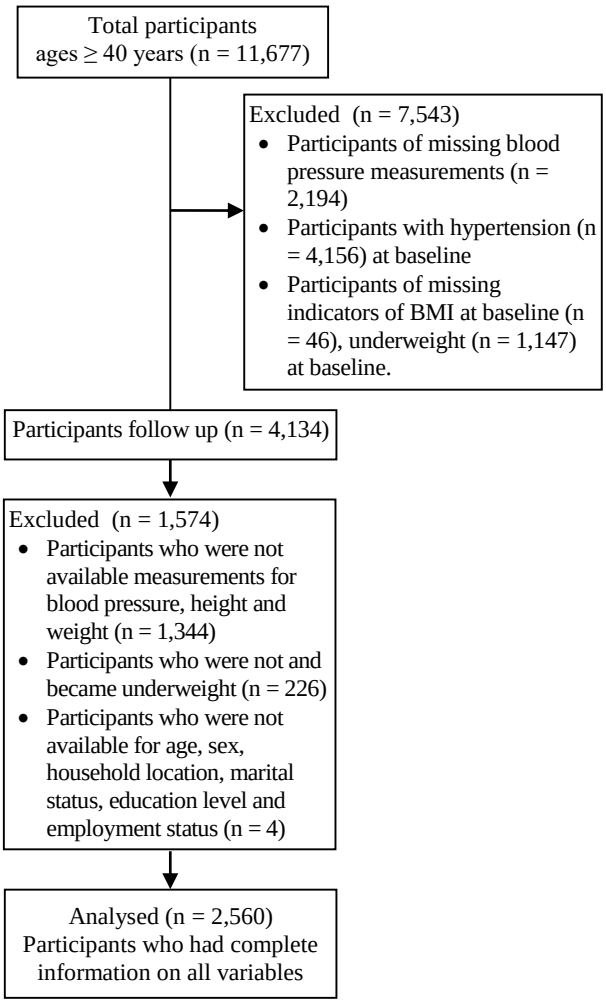

Figure 1. Flow diagram showing included and excluded participants

categories: underweight (BMI < 18.50 kg/m^2), normal weight (BMI 18.50 to 22.99 kg/m^2), overweight (BMI 22.99 to 24.99 kg/m^2), and obese (≥25.00 kg/m^2).[10,11] Based on the BMI change at Wave 3, the participants formed four weight-change groups: 1) normal weight-maintainers (normal weight at Wave 3 and Wave 5), 2) overweight or obese-gainers (normal weight at Wave 3 and become overweight or obese at Wave 5), 3) weight-losers (overweight or obese at Wave 3 and become normal at Wave 5), and 4) overweight or obese-maintainers (overweight or obese at Wave 3 and Wave 5).

Covariates. Sociodemographic factors as individual level determinants were based on self-reporting and included age (40 to 59 y, 60 and older) sex (male, female), household location (urban, rural), ethnicity (Javanese, non-Javanese), marital status (married, unmarried), education level (elementary education or less, high school completed, graduate and above), employment status (employed, unemployed).

In the univariate analysis, differences were evaluated using Chi Square tests for categorical variables. In the multivariate analysis, the ORs and 95% confidence intervals (CIs) was calculated using logistic regression models for the association between body mass index change and incident hypertension and to correct for confounding factors. To understand the effect of age on the relationships between the body weight changes and hypertension, was used stratified analysis. For the stratified analysis, the total population were divided into two subgroups according to age (40–59 and ≥60 years) and established a multivariate model for every subgroup to evaluate whether the correlations changed with age. All data were analyzed by using SPSS 18. All p-value were 2-tailed, and a p value of <0.05 was considered statistically significant.

Results

Of 11,677 participants aged ≥40 years, 9,483 (81.2%) have a complete information on blood pressure, 4,156 had a previous history of hypertension, 5,281 have a complete information of height and weight at baseline. We analysed data from 2,560 respondents for whom complete information on all included variables were were available (Figure 1).

Detailed information about the total participants and each age-based subgroup is presented in Table 1. Among 40–59 aged years, 53.6% were female, 59.7% had normal weight, 53.4% live in rural, 89.8% were married, 70.3% had an educational level of elementary or less, 76.3% were employed and more than sixty six percent were Javanese. Among 60 aged years and older, 57.3% were female, 71.8% had normal weight, 68.2% live in rural areas, 72.7% were married, 87.3% had elementary education or less, 69.1% were employed and more than sixty six percent were Javanese.

Table 1. Baseline characteristics of study sample, by age group

Variables	Total sample (n = 2,560) n (%)	Age Group 40−59 y (n = 2,340) n (%)	Age Group 60+ y (n = 220) n (%)
Sex			
Male	1179 (46.1)	1085 (46.4)	94 (42.7)
Female	1381 (53.9)	1255 (53.6)	126 (57.3)
BMI			
Normal	1556 (60.8)	1398 (59.7)	158 (71.8)
Overweight/Obese	1004 (39.2)	942 (40.3)	62 (28.2)
Household location			
Rural	1400 (54.7)	1250 (53.4)	150 68.2)
Urban	1160 (45.3)	1090 (46.6)	70 (31.8)
Marital status			
Married	2262 (88.4)	2102 (89.8)	160 (72.7)
Unmarried	298 (11.6)	238 (10.2)	60 (15.5)
Education level			
Elementary education or less	1836 (71.7)	1644 (70.3)	192 (87.3)
High school completed	582 (22.7)	559 (23.9)	23 (10.5)
Graduate and above	142 (5.5)	137 (5.9)	5 (2.3)
Employment status			
Employed	1937 (75.7)	1785 (76.3)	152 (69.1)
Unemployed	623 (24.3)	555 (23.7)	68(30.9)
Etnicity			
Non-Javanese	853 (33.3)	779 (33.3)	74 (33.6)
Javanese	1707 (66.7)	1561 (66.7)	146 (66.4)

The proportion of people with hypertension was higher among middle aged than the elderly and higher among females than males. The proportion of hypertension significantly differ acros BMI categories at baseline. The participants who were overweight or obese at baseline have a higher rate of hypertension than those with normal weight. Participants who live in urban location have a higher hypertension proportion than those who live in rural and who were unmarried than those who were married. The proportion of hypertension did not significantly differ acros educational level, employment status and ethnicity (Table 2).

To further understand the effect of age on the relationship between body weight changes and hyper-tension, stratified logistic regression was used. The steps of the statistical analysis and the results are shown in Table 3. The stratified logistic regression analysis showed that changes in the relationships between the BMI changes and hypertension with age generally tended to be positive (OR > 1) in the younger age-based subgroups (40–59 years) but negative (OR < 1) in the older subgroups (≥60 years).

The significance of the relationships differed between BMI change and age-based subgroups. BMI change was significantly positively correlated with hypertension in the 40–59 subgroups, whereas no significant correlation between BMI change and hypertension was found in the ≥60 subgroups.

This study showed significant increased hypertension risk only among the middle age subgroups. After adjustment for age, sex, ethnicity, household location, marital status, education level and employment status, the risk developing hypertension compared to subjects with normal BMI at baseline was essentially unchanged. Table 3 showed that among 40–59 subgroups, compared with the risk for whom with normal BMI at baseline (2000) who remained so at 2014, participants who were overweight or obese at baseline who remained over-weight or obese at 2014 (overweight/obese maintainers)

Table 2. Differences in covariates between hypertension group and non hypertension

Variables	Hypertension (n=1,223)	No hypertension (n=1,337)	Total	*p**
Age				<0.001
40–59 y	1081(46.2)	1259(53.8)	2340(91.4)	
≥60 y	142(64.5)	78(35.5)	220(8.6)	
Sex				<0.001
Male	510(43.3)	669(56.7)	1179(46.05)	
Female	713(51.6)	668(48.4)	1381(53.95)	
BMI				0.001
Normal	703(45.2)	853(54.8)	1556(60.78)	
Overweight/Obese	520(51.8)	484(48.2)	1004(39.22)	
Household location				0.027
Rural	641(45.8)	759(54.2)	1400(54.69)	
Urban	582(50.2)	578(49.8)	1160(45.31)	
Marital status				0.003
Married	1056(46.7)	1206(53.3)	2262(88.36)	
Unmarried	167(56.0)	131(44.0)	298(11.64)	
Education level				0.577
Elementary education or less	889(48.4)	947(51.6)	1836(71.72)	
High school completed	269(46.7)	313(53.8)	582(22.73)	
Graduate and above	65(45.8)	77(54.2)	142(5.55)	
Employment status				0.143
Employed	909(46.9)	1028(53.1)	1937(75.66)	
Unemployed	314(50.4)	309(49.6)	623(24.34)	
Etnicity				0.240
Non-Javanese	393(46.1)	460(53.9)	853(33.32)	
Javanese	830(48.6)	877(51.4)	1707(66.68)	
BMI Change				<0.001
Normal-weight maintainers	452(42.1)	622(57.9)	1074(41.95)	
Weight gainers	251(52.1)	231(47.9)	482(18.83)	
Weight losers	57(42.5)	77(57.5)	134(5.24)	
Overweight/Obese maintainers	463(53.2)	407(46.8)	870(33.98)	

***p-values* were calculated by using the chi-square test

Table 3. Likehood ratios of the impact of body mass index change on hypertension among 40–59 years subgroup and ≥60 years subgroups

Characteristics	Unadjusted		Adjusted	
	OR 95%CI	*p*	OR 95%CI	*p**
Age 40–59 y				
Sex			-	-
Male	Ref.	0.152		
Female	1.15 (0.95–1.38)			
Household location			-	-
Rural	Ref.	0.080		
Urban	1.16 (0.98–1.38)			
Marital status			-	-
Married	Ref.	0.040		
Unmarried	1.34 (1.01–1.78)			
Employment status			-	-
Employed	Ref.	0.952		
Unemployed	1.00 (0.82–1.24)			
Etnicity				
Non-Javanese	Ref.	0.952		
Javanese	1.00 (0.82–1.24)			
BMI Change				
Normal weight maintainers	Ref.	<0.001	Ref.	<0.001
Weight gainers	1.50 (1.19–1.88)	<0.001	1.54 (1.23–1.93)	<0.001
Weight losers	1.13 (0.76–1.67)	0.551	1.17 (0.79–1.72)	0.434
Overweight or obese maintainers	1.56 (1.28–1.91)	<0.001	1.68 (1.39–2.03)	<0.001
Age ≥ 60 y				
Sex				
Male	Ref.	<0.001	Ref.	<0.001
Female	4.19 (1.98–8.87)		2.90 (1.61–5.27)	
Household location			-	-
Rural	Ref.	0.976		
Urban	1.01 (0.52–1.98)			
Marital status			-	-
Married	Ref.	0.099		
Unmarried	0.50 (0.50–1.95)			
Employment status			-	-
Employed	Ref.	0.982		
Unemployed	0.99 (0.51–1.95)			
Etnicity			-	-
Non-Javanese	Ref.	0.012		
Javanese	2.20 (1.19–4.08)			
BMI Change				
Normal weight maintainers	Ref.	0.163	Ref.	0.085
Weight gainers	1.61 (0.68–3.79)	0.277	0.09 (0.71–3.78)	0.241
Weight losers	0.34 (0.10–1.11)	0.075	0.31 (0.10–0.94)	0.038
Overweight or obese maintainers	0.99 (0.44–2.21)	0.977	1.02 (0.47–2.19)	0.967

* Adjusted for sex, household location, marital status, etnicity and employment status

had a greatest risk of developing hypertension (OR = 1.68 95%CI [1.39–2.03]). Participants who were normal weight at baseline but overweight or obese at 2014 (overweight or obese gainers group) had 1.5 times increased risk of developing hypertension (OR = 1.54 95%CI [1.23–1.93]) when compared to participants who were of normal BMI at baseline and at 2014. The small number of participants who were overweight or obese at baseline but who lost weight at 2014 had odds ratio of 1.17, 95% CI (0.79–1.72).

Among the older subgroups, the present results indicate that the hypertension development associated with the body weight change might be dependent upon the gender. Therefore stratified analysis was repeated for this group (Table 4). Table 4 showed that in elderly men subgroups, there were two variables significantly associated with hypertension (Model 2). Javanese ethnic men had a five times increased risk of hypertension than non Javanese men (OR=4.95 95%CI [1.81–13.57]). Compared with the risk for whomwith normal weight

Table 4. Likehood ratios of the impact of body mass index change on hypertension among ≥60 years subgroups

Characteristics	Model 1		Model 2	
	OR 95%CI	*p*	OR 95%CI	*p*
Men				
Household location			-	-
Rural	Ref.	0.915		
Urban	1.06 (0.37–2.99)	0.070		
Marital status			-	-
Married	Ref.	0.521		
Unmarried	2.41 (0.16–35.46)			
Employment status			-	-
Employed	Ref.	0.049*		
Unemployed	0.29 (0.08–0.99)			
Etnicity				
Non-Javanese	Ref.	0.002*	Ref.	0.002*
Javanese	5.43 (1.89–15.55)		4.95 (1.81–13.57)	
BMI Change				
Normal weight maintainers	Ref.	0.028*	Ref.	0.021*
Weight gainers	5.24 (1.23–22.40)	0.026*	4.58 (1.19–17.60)	0.027*
Weight losers	0.10 (0.01–1.13)	0.063	0.10 (0.11–0.94)	0.044*
Overweight or obese maintainers	0.88 (0.21–3.74)	0.862	0.88 (0.22–3.49)	0.856
Women				
Household location			-	-
Rural	Ref.	0.395		
Urban	0.65 (0.25–1.74)			
Marital status			-	-
Married	Ref.	0.078		
Unmarried	0.46 (0.19–1.09)			
Employment status			-	-
Employed	Ref.	0.160		
Unemployed	1.91 (0.77–4.73)			
Etnicity			-	-
Non-Javanese	Ref.	0.331		
Javanese	1.54 (0.64–3.71)			
BMI Change			-	-
Normal weight maintainers	Ref.	0.853		
Weight gainers	0.81 (0.25–2.58)	0.716		
Weight losers	0.62 (0.12–3.13)	0.564		
Overweight or obese maintainers	1.18 (0.41–3.44)	0.756		

*significant at 0.05 level

maintainers group, the men who become overweight or obese had greater risk of developing hypertension (OR=4.58 95%CI [1.19–17.60]). Elderly men who were weight loser had a smaller odds ratio (OR=0.10 95% CI (0.11–0.94). While in the women elderly subgroup, there were no variables that have a significant association with the risk of hypertension development.

Discussion

In this large retrospective cohort study, 41.95% of adult and older people maintained a normal weight, 18.83% became overweight or obese status, 33.98% maintained an overweight or obese status, while 5.24% shifted to a lower BMI category. This present study shown a strong association between changes in BMI with an increased risk of hypertension after 14 years of follow-up.

In the middle age group, who were normal weight at baseline and became overweight or obese after 14 years of follow-up were 1.54 times as likely to develop hypertension than those who were maintained a normal weight. In this younger cohort, they who were of overweight or obese at baseline and remained overweight or obese after 14 years of follow-up were 1.68 times likely to develop hypertension than they who were of maintained a normal weight. This finding is consistent with previous retrospective[12] (12) and cross sectional studies[13] showing that obesity is a strong risk factor for hypertension. Previous study found that higher weight

gain was associated with higher BP.[14] Another study found that people in the higher trajectory groups (overweight-stable, obese I-stable, and "Obese II-stable), were more likely to report hypertension compared to their normal weight counterparts.[15]

Mechanisms responsible for the association of rising BMI trend with hypertension are most linked to water and salt metabolism and regulation of sodium excretion. Obesity leads to the up-regulation of renin–angiotensin–aldosterone axis and sodium and fluid retention. Moreover, leptin, the hormone produced by adipose tissue, is excessively secreted in obesity. This adipokine stimulates the sympathetic sensitivity of the kidney, which may lead to excessive sodium and fluid retention.[16] Obesity is associated also with other negative metabolic efects, like the atherogenic changes in fasting and postprandial lipoprotein profle.

As described above, it appears that elevated body weight is positively correlated with hypertension in middle-aged individuals but that this positive association declines with increasing age and tended to become negative for elderly subjects. The aging process brings about many changes in body composition. In general, as individuals age, percent body fat increases and lean mass and bone mineral density decrease. The changes in body composition are due to alterations in energy balance, with a positive energy balance leading to weight gain and a negative balance resulting in weight loss.[17] Previous prospective study found that weight loss is inversely associated with the probability of uncontrolled hypertension in obese and overweight hypertensives.[16]

A meta-analysis of 25 studies found a linear relationship between weight loss and blood pressure and showed that the decrease in weight by 1 kg is associated with app-roximately 1 mmHg decline in SBP.[16] Although the exact mechanism of the relation between hypertension and obesity and the effect of weight loss on BP is unknown, there are several plausible biologic pathways. The renin−angiotensin−aldosterone system is overactivated in obese subjects, and renin activity and aldosterone concentrations are higher than in lean subjects.[18] The concentration of ghrelin, the hormone produced by the gastric mucosa during fasting period that stimulates the excretion of sodium, is rises during weight loss. In animals, ghrelin increase results in the reduction of BP. Increase in ghrelin concentration stimulated by weight loss might contribute to the improvement of BP control.[16]

In addition, this study found that ethnicity may play an important role in determining the predictive power for hypertension in elderly men groups. The consideration of race/ethnicity also introduces a set of variables that extend beyond genetics.[19] Different ethnicities often differ in socioeconomic status, cultural factors, lifestyles, food habits and physical activity levels, and ethnic groups may have different combinations of genes that are associated with hypertension and gene-environment interactions that may lead to the variation in blood pressure.[20]

The present study has a number of strengths. Few studies have examined the change of body mass index and risk of hypertension. This study is one of the first examine the change of BMI on incidence of hypertension especially in the Indonesian population. The large size of the study sample is also a strength of this study. The IFLS survey is a nationally-representative sample with high response rate and used the standardized methodology. Indeed study sample provides the only nationally representative, longitudinal sample with measured height and weight spans the middle adult and older adult years.

There are several limitations to this study. First, although BMI has been accepted as satisfactory index of underweight and obesity, it cannot be used to identify distributions of fat and muscle tissue. Second, possible individual changes in the body mass index during the follow-up may have influenced the results. Third, as a result of stratification by age group, there was a possibility of beta error because of inadequate numbers of participants and events.[21]

In summary, recent findings are consistent with some previous population-based studies which showed that sustained weight loss during adult life had a stronger apparent protective effect on hypertension development, whereas excessive weight gain (relative to the population) was associated with higher risk of hypertension at midlife. A stronger association between BMI changes in the younger cohort suggests that BMI-related effects may have been offset by improvements in other factors linked to BP; for example, in detection and treatment of hypertension.

Conclusions

The temporal relationship established by the long follow up and repeated assessment of both body weight and blood pressure provides strong evidence for the association between trajectories of BMI and incident hypertension. This findings suggest even a modest gain in weight beginning early in life was associated with a substantially higher risk of hypertension. On the basis of this fndings, it can be assumed that even maintenance of a stable weight is benefcial compared to weight gain in terms of appropriate hypertension control.

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Conflict of Interest Statement

The authors declare no conflicts of interest associated with the work described in this manuscript.

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