HHS Public Access

Author manuscript

Hypertension. Author manuscript; available in PMC 2016 August 01.

Published in final edited form as:

Hypertension. 2015 August ; 66(2): 286–293. doi:10.1161/HYPERTENSIONAHA.114.04863.

Is the Association of Hypertension with Cardiovascular Events Stronger Among the Lean and Normal Weight than Among the Overweight and Obese? The Mesa Study

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Abstract

Previous studies that suggest the association of hypertension with cardiovascular disease (CVD) events is stronger in the lean/normal weight than in the obese have either included smokers, diabetics, or cancer patients, or did not account for central obesity. This study examines the interaction of adiposity with hypertension on CVD events using BMI-based definitions of overweight and obesity as well as waist circumference (WC) to assess adiposity.

In the Multi-Ethnic Study of Atherosclerosis, we classified 3657 nonsmoking men and women, free of baseline clinical CVD, diabetes and cancer, into 7 BMI-WC combinations defined by ethnicity-specific BMI (normal, overweight, class 1 obese, and class 2/3 obese) and ethnicity- and sex-specific WC categories (optimal or nonoptimal). Adjusted absolute event rates per 1000 person-years and relative risks (RRs) (95% confidence intervals) for CVD events for hypertension (BP ≥ 140/90 or taking medication) vs. no hypertension computed within adiposity categories were: 9.3 vs. 1.9 and 4.96 (2.56-9.60) for normal BMI/optimal WC, 13.2 vs. 4.2 and 3.13 (0.99-9.86) for normal BMI/nonoptimal WC, 9.0 vs. 4.5 and 2.00 (1.19-3.36) for overweight BMI/optimal WC, 8.4 vs. 5.6 and 1.50 (0.88-2.54) for overweight BMI/nonoptimal WC,14.1 vs. 2.1 and 6.75 (0.69-65.57) for class 1 obese/optimal WC, 10.1 vs. 3.7 and 2.69 (1.41-5.16) for class 1 obese/nonoptimal WC, and 9.9 vs. 6.9 and 1.45(0.60-3.52) for class 2/3 obese/WC pooled.

This study found a large RR of CVD events associated with hypertension for normal BMI participants and more importantly similarly high absolute risks for both normal and obese BMI with hypertension.

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Disclosures: None.

Keywords

hypertension; obesity; blood pressure; cardiovascular disease; waist circumference; follow-up studies; risk

Introduction

Hypertension is a leading risk factor for cardiovascular disease (CVD) morbidity and mortality. Prevalence of hypertension in the United States was estimated to be 28.6% for 2009-2010.[1] While overweight and obesity are among the strongest risk factors for hypertension,[2] hypertension is fairly common in individuals with normal weight. One study reported an age-adjusted prevalence of 20.5% for a body mass index (BMI) of <25 kg/m^2 in 2003-2004 for a US population.[3]

It has been suggested that obesity modifies the relation between blood pressure (BP) and CVD, with the adverse effect of hypertension being stronger in the lean and normal weight than in the obese. Some,[4-7] but not all[8,9] studies support this hypothesis. Some of these studies, however, have been criticized because they used BMI as the sole index of obesity without accounting for central adiposity, or included smokers, cancer patients, or people with diabetes.[10]

The Multi-Ethnic Study of Atherosclerosis (MESA) provides an opportunity to examine the possible interaction between obesity or overweight and hypertension in a subsample that excludes smokers and individuals with diabetes or cancer. In the present study we examine the association of hypertension with CVD events using BMI-based definitions of overweight and obesity and, as recommended by a 2011 American Heart Association Scientific Statement, also waist circumference (WC) to assess adiposity.[11]

Methods

Study participants

MESA is a population-based study initiated in 2000 to investigate the prevalence and progression of subclinical CVD in a sample of 6814 non-Hispanic white, African-American, Chinese-American and Hispanic men and women, aged 45-84 years, who were free of clinical CVD at baseline and were recruited from six US communities. Details on the design, recruitment, and cohort examination procedures have been published.[12] All participants gave informed consent, and the MESA protocol was approved by the Institutional Review Board at each site.

For the present analysis, we excluded current smokers (n=887) and those who began smoking at a subsequent visit (n=145), those with a baseline history of cancer (n=491) and those with incident cancer during follow-up (n=423), and participants with diabetes at baseline (n=605) or follow-up (n=496), those missing essential covariates (n=79) and 1 with a pre-baseline CVD event. This left 3687 who were classified in five categories of BMI and two categories of WC. For Caucasians, Hispanics, and African Americans, the BMI categories were underweight: <18.5 kg/m^2, normal: 18.5-24.9 kg/m^2, overweight: 25.0-29.9

kg/m^2, class 1 obese: 30.0-34.9 kg/m^2, and class 2/3 obese: ≥35.0 kg/m^2. For Chinese, the categories were <18.5 kg/m^2 for underweight, 18.5 to 22.9 kg/m^2 for normal, 23.0 to 27.4 kg/m^2 for overweight, and ≥27.5 kg/m^2 for obese. A BMI ≥30.0 kg/m^2 for Chinese was taken to correspond to the class 2/3 obese category for the other 3 ethnicities based on the findings of Gu et al.[13] Optimal WC was taken to be <102 cm in men and <88 cm in women, for Caucasians, Hispanics, and African Americans, and <90 cm and <80 cm for Chinese men and women, respectively. The BMI and WC cutpoints are based on the 2013 AHA/ACC/TOS Guideline for the Management of Overweight and Obesity in Adults[14] and two reports from the World Health Organization.[15,16] Table 1 shows the frequencies of men and women according to BMI and WC. The underweight BMI categories had too few participants to include in statistical analysis, and so are excluded from the analytic cohort for the primary analysis. In addition, in the sex-specific analyses, the Normal BMI-non-optimal WC category for men and the Obese 1-optimal WC category for women had too few participants to include for their respective analyses. Finally, because WC adds little to the predictive ability of the disease risk classification of BMI ≥35 kg/m^2,[14] the WC categories for Class 2/3 obese were pooled. Thus, the primary analysis included 3657 men and women classified into seven BMI-WC categories.

Data Collection

Data were collected by trained and certified technicians. Three BP measurements (one minute apart) were collected using Dinamap model Pro100 (Critikon, GE Healthcare, Waukesha, Wisconsin) and the averages of the second and third measurements were used. Information on participant demographics, smoking status, alcohol intake, physical activity, medical history, and medication usage was collected with standardized questionnaires. Height, weight, and WC were measured with participants wearing light clothing and no shoes. WC was measured at the level of the umbilicus and BMI was calculated as weight (kg)/height (m^2). Hypertension was defined as systolic BP ≥140 mmHg or diastolic BP ≥90 mmHG or taking an antihypertension medication.

Incident CVD events were recorded over a mean follow-up of 10.3 (SD: 2.67) years. At intervals of 9-12 months, a telephone interviewer contacted each participant to inquire about all interim hospital admissions, cardiovascular outpatient diagnoses and procedures, and deaths. Other details regarding follow-up and adjudication are given elsewhere.[17] All CVD events included myocardial infarction, resuscitated cardiac arrest, definite angina, probable angina (if followed by revascularization), CHD death, stroke, stroke death, other atherosclerotic death, and other CVD death.

Statistical Analysis

Statistical analysis was conducted using SAS for Windows, release 9.4 (SAS Institute Inc., Cary, NC). In a preliminary analysis, two-way interactions of BMI groupXhypertension status and WC groupXhypertension status were first assessed. Subsequently, a more thorough analysis was done. Poisson regression, implemented through PROC GENMOD, was used to estimate multivariable adjusted rates of all CVD events for the seven BMI-waist categories by hypertension status. Relative risk (RR) ratios as well as rate differences were computed. Tests for multiplicative interaction between the seven BMI-waist categories and hypertension status were obtained through the “type 3” option of PROC GENMOD. As a measure of additive interaction, the relative excess risk due to interaction (RERI) and its 95% confidence intervals (CIs) were computed using the method of Li and Chambless.[18] The models were run for all participants, then separately for each sex and were adjusted for age (4 categories: 45-54, 55-64, 65-74, and 75-84 years), ethnicity, LDL-cholesterol (5 NCEP categories: <100, 100-129, 130-159, 160-189, 190+), HDL-cholesterol (3 NCEP categories: 60+, 40-59, <40), triglycerides (4 NCEP categories: <150, 150-199, 200-499, 500+), cholesterol medication, current drinking status, education (3 categories: less than High School, High School or some college, Bachelor's degree or more), and total intentional exercise (4 quartiles). Also, to provide risk estimates for 4 BMI categories (normal, overweight, class 1 obese, and class 2/3obese) without accounting for WC, as these would be more comparable with previous studies and perhaps more generalizable when WC is not considered, Poisson regression models were run without adjusting for WC. We conducted two sensitivity analyses. In the first, after excluding participants with extreme energy intake (i.e. fewer than 600 kcal or greater than 6000 kcal/day), we further adjusted the primary model for the dietary factors, sodium, potassium, calcium, magnesium, and total energy intake. In the second, to examine the effect of including smokers, and participants with diabetes or cancer on the risk estimates, we included those subjects in an additional analysis. Additional adjustment for smoking status, diabetes, and history of cancer was made.

Results

Baseline characteristics are presented by BMI-Waist category for each hypertension status in Tables 2a (normal BMI and overweight) and 2b (class 1 obese and class 2/3 obese). Mean age was lower for hypertension absent compared to hypertension present for each BMI-waist group. Total intentional exercise was generally greater and higher levels of education were achieved in the hypertension absent compared to the hypertension present groups. Among the hypertension present groups, blood pressure medication usage was most prevalent among the class 2/3 obese.

The Poisson regression analysis assessing the two-way interactions yielded p-values of 0.04 and 0.32 for the BMI groupXhypertension and WC groupXhypertension interactions, respectively. Stratifying by WC, the RRs for optimal and nonoptimal WC were, respectively: 3.16 (95%CI: 2.08, 4.80) and 1.91 (95%CI: 1.32, 2.77). Stratifying by BMI, the RRs for normal, overweight, class 1 obese, and class 2/3 obese were, respectively: 3.97 (95%CI: 2.14, 7.38), 1.70 (95% CI: 1.15, 2.53), 3.12 (95% CI: 1.64, 5.95), and 1.70 (95% CI: 0.63, 4.61).

Table 3 shows the results of the Poisson regression models for the joint BMI-waist categories. With men and women pooled, the adjusted CVD event rates were higher in the hypertension present groups than in the hypertension absent groups for each BMI-waist category. In the hypertension present groups, the lowest CVD event rate was 8.4/1000 person-years in the overweight/nonoptimal group. There was some evidence of interaction of BMI-waist categories with hypertension status (p=0.08) with RRs ranging from a low of 1.45 for the class 2/3 obese to a high of 6.75 for the class 1 obese with optimal waist group. It should be noted that although the RR for the class 2/3 obese group did not differ from 1, the event rates for both hypertension absent and hypertension present were high, 6.9 and 9.9/1000 person-years, respectively. The RR for the normal BMI with optimal waist group was very high (RR=4.96) and exceeded the RR for all other BMI-waist categories except for the class 1 obese/optimal waist category, which only had 50 participants. The 95% CIs of the computed RERIs all contained zero, indicating a lack of additive interaction (data not shown). When men and women are examined separately, there is evidence of multiplicative interaction for men (p=0.05) but not for women (p=0.40). For both men and women separately, the 95% CIs of the computed RERIs all still contained zero.

We examined ethnicity specific associations (supplemental Table S1), but data were insufficient to permit reliable estimation of RRs in the Chinese-American, African-American and Hispanic groups in certain BMI-waist categories and so those categories are excluded from the analysis. In the Caucasian group, the pattern of RRs was mostly similar to those for the entire population, with the normal BMI-optimal waist group having the highest RR. In the other ethnic/race groups, none of the RRs were statistically significant for any BMI-waist category.

The estimated RRs (95%CI) for 4 BMI categories (normal, overweight, class 1 obese, and class 2/3 obese) without adjusting for WC were, respectively: 4.58 (2.57, 8.13), 1.74 (1.19, 2.54), 2.90 (1.55, 5.41), and 1.44 (0.60, 3.50). There was evidence of interaction between BMI group and hypertension status (p=0.02).

Because the designs of some studies differed from the current study in that they assessed the association of BMI with outcomes restricting the sample to participants with prevalent hypertension, we also conducted an exercise stratifying on hypertension status and estimating the hazard ratios (HR) of the 7 BMI-waist classes for all CVD events. In the hypertension group, none of the HRs for any BMI-waist group differed significantly from 1. In the order shown in Table 3 the HR (95% CI) were: 1, 1.43 (0.71, 2.89), 0.93 (0.58, 1.49), 0.85 (0.54, 1.34), 1.39 (0.42, 4.59), 1.03 (0.65, 1.64) and 1.00 (0.55, 1.83). On the other hand, in the normotensive group the HRs for all CVD events over the increasing BMI-waist groups exceeded 1: 1, 1.86 (0.57, 6.08), 2.43 (1.19, 4.96), 2.95 (1.41, 6.19), 1.28 (0.16, 10.12), 2.01 (0.87, 4.63), and 3.67 (1.38, 9.74).

In a sensitivity analysis, the primary model (i.e. Table 3) with men and women pooled was rerun with additional adjustment for sodium, potassium, calcium, magnesium, and total energy intake, all in quartiles. The event rates and risk ratios seen in Table 3 did not change notably (data not shown).

The sensitivity analysis which reintroduced the smokers and participants with diabetes and cancer to the analytic cohort is shown in supplemental Table S2. For men and women pooled, with the exception of the class 1 obese-optimal waist with hypertension group, all adjusted CVD event rates per 1000 person-years increased at least 2-fold when compared to the primary analysis that excluded smokers, and people with diabetes or cancer (Table 3). For example, whereas the adjusted rates in the hypertension absent groups in the primary analysis ranged from 1.9 to 6.9/1000 person-years, in the sensitivity analysis they ranged from 7.3 to 15.2/1000 person-years. In the hypertension present groups, the adjusted rates ranged from 8.4 to 14.1/1000 person-years in Table 3 whereas in Table S2, they ranged from 18.6 to 37.7/1000 person-years. On the other hand, the RRs for each BMI-waist category in Table 4 are mostly of similar magnitude compared to the corresponding BMI-waist category in Table 3. It is also noteworthy that the highest event rates for hypertension present were in the underweight and normal BMI categories: 30.7, 23.1, and 37.7/1000 person-years, respectively.

Discussion

In this population based sample of men and women free of clinical CVD at baseline, we documented a relative risk ratio of hypertension equal to 5.0 for all CVD events for the normal BMI-optimal waist category with men and women pooled as compared with hypertension absent. In the class 2/3 obese BMI category, while the RR did not differ significantly from 1, the absolute event rates for both hypertension present and hypertension absent were high. Moreover, the absolute risk for the normal BMI-optimal WC hypertensives was similar to that for the class 2/3 obese hypertensives. Thus, while the RR measures imply a stronger association of hypertension with CVD events among the lean/normal weight than among the obese, the absolute adjusted event rates reveal that among hypertensives, the obese have as high risk as the lean/normal weight. This is an important finding as it should discourage the notion that hypertension has less serious consequences in the obese than in the lean.

It has been suggested that the inclusion of smokers, people with diabetes, cancer, or other cachexia related conditions may have biased results of some previous studies.[9] In the Hypertension Detection and Follow-up Program (HDFP), Stamler et al.[6] attributed excess mortality in lean hypertensives to unhealthy lifestyle characteristics associated with leanness such as smoking. Thus, in the primary analysis, we excluded smokers, diabetics, and people with cancer. Notably, including these individuals in the sensitivity analysis then resulted with the lowest BMI categories having the highest event rates for the hypertension present categories, Thus, our data are in support of the HDFP findings and suggest a role for residual confounding in previous studies which included smokers, and people with diabetes or cancer.

We separated the standard BMI categories into optimal and nonoptimal WC in accordance with an AHA scientific statement recommending the additional measurement of WC.[11] In other studies, individuals with normal BMI but central obesity manifesting as a large WC have been found to have a higher risk for cardiovascular events.[19] Most previous studies did not take into account abdominal obesity in the lower BMI categories.

Regardless of the lack of accounting for abdominal obesity, several studies conducted in previous decades (reviewed in Bender et al.[9]) as well as a very large, more recent study[20] support the concept of an interaction between adiposity and hypertension with regard to CVD risk. In the samples of patients with hypertension,[20-22] the lean or normal weight exhibited more serious outcomes compared to those with obesity. The design of some studies differed from the present study, as they examined the BMI association with outcomes by restricting the analysis to the sample with prevalent hypertension and/or CVD. Recent publications[23-25] have pointed to a particular form of selection bias, referred to as "collider stratification bias", which occurs when the obesity association with outcome is restricted to the segment of the population with the prevalent disease under study, such as diabetes, heart failure, or hypertension. They speculate the existence of an unmeasured factor confounding the disease—outcome relationship, and failure to adjust for this unmeasured confounder when restricting to prevalent disease introduces bias in the obesity – outcome association in the restricted population. Extensive discussion of various forms of selection bias is provided elsewhere.[26,27] In the present study, we conducted an exercise stratifying the sample on hypertensive status and estimating the HRs of the BMI-waist classes for CVD events. In the hypertension group, none of the HRs for any BMI group compared to the reference group of normal BMI-optimal waist differed significantly from 1. On the other hand, in the normotensive group the HRs for all CVD events exceeded 2 for the groups with more than 102 participants. The "collider stratification bias" concept would imply some degree of bias in the HR estimates for the hypertension sample.

A Swedish study that included over one million young men (median age 18.2 years) did not observe an interaction with hypertension that suggested a stronger association for the lean,[28] but neither did this study restrict analysis to the hypertensive participants only (that is, excluding other morbidities). This study estimated HRs per 1 standard deviation increase in systolic and diastolic BP within BMI categories and reported the strongest association for CVD events in the obese category.[28] In contrast, the HUNT cohort study from Norway included 71,382 men and women free of known CVD at baseline and also did not restrict the analysis to hypertensive patients, and included a large proportion of smokers – approximately 33% in the subgroup with BMI < 25 kg/m^2. They found, among participants less than 65 years old, that BP had a much stronger association with mortality from ischaemic heart disease in lean than in overweight or obese people.[29]

While the present study exposes a problem of restricting attention to RR measures and the potential role for residual confounding, we cannot entirely discount that more adverse outcomes among lean hypertensives might manifest in some cohorts: previous studies have suggested mechanisms that could underlie a BMI-hypertension interaction. For instance, cardiorespiratory fitness may have a mediating role in the interaction of adiposity and hypertension with regard to coronary heart disease and heart failure risks,[30,31] this might extend to hypertension risk. In five separate studies examining objectively measured cardiorespiratory fitness in patients with CVD, higher BMI was protective for all-cause mortality among the patients with low fitness. On the other hand, among the patients with high fitness, in three of the studies, an interaction was not present.[31]

Another factor that warrants consideration is that the cardiac sympathetic nervous system has greater effects in lean hypertensives whereas the renal sympathetic nervous system has greater effects in the overweight or obese hypertensives.[29] Lambert et al.[32] described greater sympathetic outflow to the heart in normal weight hypertension as compared to obesity related hypertension, as well as different firing characteristics of individual sympathetic fibers between normal weight and obese hypertensive people. They suggested high cardiac sympathetic activity in the heart of lean hypertensive individuals might potentially contribute to left ventricular hypertrophy.[32] In addition to greater cardiac sympathetic activity, there may be a greater role in the lean for catecholamines and the renin-angiotensin system as opposed to a greater importance of insulin and lipid metabolism abnormalities in overweight and obese.[29]

Genetic determinants of CVD may be stronger in lean hypertensives.[21] Although some genome-wide association studies[33] and genetic risk score prediction models[34,35] support a genetic component to hypertension, there are few studies examining gene-environment interactions with blood pressure[36] suggesting an area for further research.

Another factor that could be examined in future studies relating to CVD risk is the composition of adipose tissue. Subcutaneous adipose tissue (SAT) and visceral adipose tissue (VAT), both of which may be measured by computed tomography or magnetic resonance imaging, have differential contributions to metabolic risk[37,38]with VAT being the more adverse component of adipose tissue. Population based studies are increasingly undertaking the measurement of ectopic fat depots and relating their components to CVD morbidity and mortality.[39] Future studies in this area will provide valuable insight into the biological pathways from adiposity to CVD risk.

Some additional limitations of the present study must be noted. This study lacked a measure of cardiorespiratory fitness and although measures of WC were available and thus could account for abdominal obesity, there were insufficient numbers of participants to allow examination of associations for underweight BMI groups. The WC measurements were also made at the level of the umbilicus, which is the least reproducible site of eight possible sites considered for this measurement.[11] Thus some misclassification into the WC categories may have occurred. There was also insufficient power for examining ethnicity specific associations. However, the MESA population was sufficiently large to permit the exclusion of smokers, people with diabetes and those with cancer.

In summary, this study found a strong association of hypertension with CVD events for normal BMI participants without abdominal obesity. However, more importantly, absolute adjusted event rates were similarly high for both hypertensive normal BMI and hypertensive obese BMI individuals. Vigilance and aggressive treatment for lean and normal weight persons as well as obese with hypertension are suggested.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

The authors thank the other investigators, the staff, and the participants of the MESA study for their valuable contributions. A full list of participating MESA investigators and institutions can be found at http://www.mesa-nhlbi.org.

Funding/Support: This research was supported by contracts N01-HC-95159, N01-HC-95160, N01-HC-95161, N01-HC-95162, N01-HC-95163, N01-HC-95164, N01-HC-95165, N01-HC-95166, N01-HC-95167, N01-HC-95168 and N01-HC-95169 from the National Heart, Lung, and Blood Institute and by grants UL1-TR-000040 and UL1-TR-001079 from the National Center for Research Resources.

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Perspectives

In a multi-ethnic cohort free of CVD at baseline and excluding smokers and participants with diabetes or cancer at baseline or follow-up, we show the association of hypertension with CVD events is heterogeneous by level of adiposity, where adiposity is defined by ethnicity specific categories of BMI (i.e. normal, overweight, class 1 obese, and class 2/3 obese) and optimal versus non-optimal WC. The association of hypertension with CVD events had greatest magnitude in participants with normal BMI and optimal WC and was much attenuated in the class 2/3 obese. However, both the class 2/3 obese with hypertension and without hypertension had high rates of CVD events and event rates for hypertensive normal BMI with optimal WC and hypertensive class 2/3 obese were similarly high. This study underscores the consequences of hypertension in normal weight individuals who do not have abdominal adiposity and, while not diminishing the importance of hypertension in the obese, should encourage greater vigilance by healthcare professionals.

Novelty and Significance

What is new?

In a cohort of individuals free of baseline CVD and excluding smokers and patients with cancer or diabetes, we investigated whether the association of hypertension with CVD events is more adverse in the lean and normal weight than in the overweight and obese.

What is relevant?

Previous studies show approximately 20% of adults with BMI < 25 kg/m^2 have hypertension. We show hypertension in such individuals who do not have abdominal adiposity is associated with high absolute risk of adverse CVD events that is similar in magnitude to the absolute risk for hypertensive class 2/3 obese individuals.

Summary

Although the association of hypertension with CVD events is stronger among the lean/normal weight than it is among the class 2/3 obese, the relative risk estimates used to portray such relations obscure an equally important finding that the absolute risk for CVD events for lean/normal weight hypertensive individuals is high but similar to that for obese hypertensive individuals.

Table 1

Frequencies of BMI-Waist Categories for All Participants and by Gender

BMI† by Waist Categories‡	All Participants (N=3687)		Men (N=1641)		Women (N=2046)	
	Optimal waist	Not Optimal waist	Optimal waist	Not Optimal waist	Optimal waist	Not Optimal waist
Underweight	30*	0*	13*	0*	17*	0*
Normal	876	178	422	6*	454	172
Overweight	754	814	584	222	170	592
Class 1 obese	50	654	44	272	6*	382
Class 2/3 obese	2	329	0	78	2	251

* excluded from analytic sample due to small number

† BMI ranges for Underweight, Normal, Overweight, Class 1 obese 1, and Class 2/3 obese categories are, in kg/m^2, respectively: <18.5, 18.5 – 24.9, 25-29.9, 30-34.9, and ≥35 in Caucasians, African Americans, and Hispanics, and are: < 18.5, 18.5-22.9, 23-27.4, 27.5-29.9, and ≥30 in Chinese.

‡ Optimal waist is <102cm in men and < 88cm in women for Caucasian, African American, and Hispanic ethnicity, and <90 cm in men and <80cm in women for Chinese ethnicity.

Table 2

Baseline characteristics of the Participants by BMI-Waist categories and Hypertension Status

Baseline Characteristics*	Normal BMI†				Overweight BMI†				Class 1 Obese†				Class 2 or 3 Obese†	
	Optimal waist‡		Non-optimal waist‡		Optimal waist‡		Non-optimal waist‡		Optimal waist‡		Non-optimal waist‡		Optimal or nonoptimal waist‡	
	Hypertension status		Hypertension status		Hypertension status		Hypertension status		Hypertension status		Hypertension status		Hypertension status	
	Absent	Present	Absent	Present	Absent	Present	Absent	Present	Absent	Present	Absent	Present	Absent	Present
N	605	271	102	76	458	296	426	388	32	18	307	347	137	194
Age, years	58.8 (9.7)	67.2 (9.8)	63.8 (10.0)	69.9 (8.5)	57.5 (9.9)	64.3 (9.3)	59.6 (9.6)	68.0 (9.0)	57.6 (11.1)	60.7 (9.2)	57.8 (9.4)	64.3 (9.0)	56.5 (8.5)	62.2 (9.5)
Male (%)	288 (47.6)	134 (49.5)	2 (2.0)	4 (5.3)	355 (77.5)	229 (77.4)	115 (27.0)	107 (27.6)	31 (96.9)	13 (72.2)	131 (42.7)	141 (40.6)	35 (25.6)	43 (22.2)
Race (%)														
Caucasian	318 (52.6)	127 (46.9)	43 (42.2)	31 (40.8)	188 (41.1)	95 (32.1)	159 (37.3)	147 (37.9)	10 (31.3)	8 (44.4)	130 (42.4)	118 (34.0)	47 (34.3)	58 (29.9)
Chinese	117 (19.3)	39 (14.4)	36 (35.3)	20 (26.3)	57 (12.5)	24 (8.1)	85 (20.0)	71 (18.3)	0 (0.0)	0 (0.0)	16 (5.2)	22 (6.3)	10 (7.3)	6 (3.1)
Black	84 (13.9)	63 (23.3)	5 (4.9)	12 (15.8)	89 (19.4)	104 (35.1)	63 (14.8)	98 (25.3)	12 (37.5)	8 (44.4)	75 (24.4)	130 (37.5)	48 (35.0)	101 (52.1)
Hispanic	86 (14.2)	42 (15.5)	18 (17.7)	13 (17.1)	124 (27.1)	73 (24.7)	119 (27.9)	72 (18.6)	10 (31.43)	2 (11.1)	86 (28.0)	77 (22.2)	32 (23.4)	29 (15.0)
Current drinker (%)	380 (62.8)	151 (55.7)	50 (49.0)	38 (50.0)	296 (64.6)	175 (59.1)	219 (51.4)	188 (48.5)	17 (53.1)	11 (61.1)	171 (55.7)	179 (51.6)	79 (57.7)	95 (49.0)
Education Level (%)														
Less than HS	65 (10.7)	54 (19.9)	15 (14.7)	17 (22.4)	63 (13.8)	46 (15.5)	92 (21.6)	83 (21.4)	6 (18.8)	4 (22.2)	44 (14.3)	67 (19.3)	15 (11.0)	34 (17.5)
HS or some college	224 (37.0)	114 (42.1)	47 (46.1)	37 (48.7)	175 (38.2)	138 (46.6)	182 (42.7)	184 (47.2)	11 (34.4)	4 (22.2)	135 (44.0)	167 (48.1)	72 (52.6)	113 (58.3)
BS or higher degree	316 (52.2)	103 (38.0)	40 (39.2)	22 (29.0)	220 (48.0)	112 (37.8)	152 (35.7)	121 (31.2)	15 (46.9)	10 (55.6)	128 (41.7)	113 (32.6)	50 (36.5)	47 (24.2)
Total Intentional exercise, MET-minutes/week	1919 (2709)	1775 (2448)	1647 (2033)	1122 (1085)	1939 (2556)	1895 (2997)	1281 (1755)	1683 (2569)	2494 (4507)	1209 (1295)	1348 (1994)	1372 (1913)	1398 (2473)	931 (1316)
LDL, mg/dL	116 (31)	113 (27)	121 (30)	115 (33)	121 (31)	120 (31)	124 (32)	116 (32)	123 (22)	121 (30)	122 (29)	118 (32)	123 (30)	118 (31)
HDL, mg/dL	59 (17)	60 (19)	60 (15)	61 (16)	49 (12)	50 (14)	51 (13)	53 (14)	44 (10)	49 (12)	49 (13)	51 (14)	49 (13)	50 (12)
Triglycerides, md/dL	97 (53)	105 (52)	124 (60)	116 (50)	115 (57)	119 (65)	134 (68)	133 (62)	140 (90)	120 (60)	132 (65)	134 (66)	128 (66)	126 (68)
Lipid lowering med. (%)	51 (8.4)	44 (16.2)	10 (9.8)	13 (17.1)	54 (11.8)	62 (21.0)	36 (8.5)	77 (19.9)	2 (6.3)	3 (16.7)	33 (10.8)	67 (19.3)	15 (11.0)	36 (18.6)
SBP, mmHg	110 (14)	139 (24)	113 (15)	143 (21)	115 (12)	137 (19)	115 (13)	139 (21)	121 (13)	139 (21)	117 (11)	138 (22)	118 (12)	138 (23)
DBP, mmHg	67 (9)	75 (11)	65 (9)	72 (10)	72 (8)	78 (10)	68 (8.7)	74 (10)	74 (7)	79 (11)	70 (8)	76 (11)	68 (8)	74 (12)
BP med. (%)	0 (0.0)	184 (67.9)	0 (0.0)	51 (67.1)	0 (0.0)	208 (70.3)	0 (0.0)	193 (75.5)	0 (0.0)	11 (61.1)	0 (0.0)	264 (76.1)	0 (0.0)	158 (81.4)
Number of meds	2.0 (2.2)	3.8 (2.8)	2.7 (2.8)	3.8 (2.8)	1.7 (2.0)	3.3 (2.6)	2.2 (2.4)	4.3 (2.9)	1.5 (2.0)	3.6 (3.3)	2.0 (2.2)	4.0 (2.7)	2.6 (2.7)	4.7 (3.1)

* Data are mean (SD) or n (%).

†BMI ranges for Normal, Overweight, Class 1 Obese, and Class 2/3 Obese categories are, in kg/m^2, respectively: 18.5 – 24.9, 25-29.9, 30-34.9, and ≥35 in Caucasians, African Americans, and Hispanics, and are: 18.5-22.9, 23-27.4, 27.5-29.9, and ≥30 in Chinese.

‡Optimal waist in Caucasians, African American, and Hispanics is <102 cm in men and <88cm in women, and for Chinese is <90 cm in men and <80cm in women.

Table 3

Multivariable Adjusted* Rates/1000 Person-years and Risk Ratios (RR) for All CVD Events According to Presence of Hypertension and Adiposity, Shown for All Participants and for Men and Women Separately

		Men & Women Pooled (N=3657)				Men (N=1622)			Women (N=2023)		
BMI†-Waist‡ category	**Hypertension exposure §**	**# of events/ total N**	**Adj. rate/ 1000 per-yrs***	**RR (95% CI), p-value**	**Absolute difference**	**Adj. rate/ 1000 per-yrs***	**RR (95% CI), p-value**	**Absolute difference**	**Adj. rate/ 1000 per-yrs***	**RR (95% CI), p-value**	**Absolute difference**
Normal BMI and Optimal waist	Absent	12/605	1.9	1.0		3.1	1.0		0.9	1.0	
	Present	37/271	9.3	4.96 (2.56-9.60), <0.0001	7.4	20.4	6.56 (2.95-14.58), <0.0001	17.3	2.6	2.95 (0.88-9.93), 0.08	1.7
Normal BMI and Nonoptimal waist	Absent	4/102	4.2	1.0			NA		2.4	1.0	
	Present	11/76	13.2	3.13 (0.99-9.86), 0.05	9.0				7.5	3.10 (0.98-9.85), 0.05	5.1
Overweight BMI and Optimal waist	Absent	24/458	4.5	1.0		7.4	1.0		1.6	1.0	
	Present	38/296	9.0	2.00 (1.19-3.36), 0.009	4.5	15.5	2.10 (1.21-3.62), 0.008	8.1	3.1	1.91 (0.31-11.65), 0.48	1.5
Overweight BMI and Nonoptimal waist	Absent	22/426	5.6	1.0		7.6	1.0		3.5	1.0	
	Present	42/388	8.4	1.50 (0.88-2.54), 0.14	2.8	15.8	2.07 (0.89-4.81), 0.09	8.2	3.8	1.08 (0.54-2.18), 0.82	0.3
Class 1 obese and Optimal waist	Absent	1/32	2.1	1.0		3.4	1.0			NA	
	Present	3/18	14.1	6.75 (0.69-65.57), 0.10	12.0	28.8	8.36 (0.85-82.06), 0.07	25.4			
Class 1 obese and Nonoptimal waist	Absent	12/307	3.7	1.0		4.9	1.0		2.5	1.0	
	Present	42/347	10.1	2.69 (1.41-5.16), 0.003	6.4	11.5	2.36 (0.91-6.07), 0.08	6.6	7.9	3.22 (1.30-7.94), 0.01	5.4
Class 2/3 obese	Absent	7/137	6.9	1.0	3.0	13.8	1.0	-3.0	3.1	1.0	3.4
	Present	18/194	9.9	1.45 (0.60-3.52) 0.41		10.6	0.77 (0.19, 3.16) 0.72		6.5	2.12 (0.60-7.58) 0.25	

			Men & Women Pooled (N=3657)			Men (N=1622)			Women (N=2023)		
BMI[†]-Waist[‡] category	**Hypertension exposure §**	**# of events/ total N**	**Adj. rate/ 1000 per-yrs***	**RR (95% CI), p-value**	**Absolute difference**	**Adj. rate/ 1000 per-yrs***	**RR (95% CI), p-value**	**Absolute difference**	**Adj. rate/ 1000 per-yrs***	**RR (95% CI), p-value**	**Absolute difference**
p-value (BMI-Waist X Hypertension)				0.08			0.05			0.40	

*Adjusted rates/1000 person-years: adjusted for age (4 age categories: 45-54, 55-64, 65-74, and 75-84 years), ethnicity, LDL-cholesterol (5 NCEP categories: <100, 100-129, 130-159, 160-189, 190+), HDL-cholesterol (3 NCEP categories: 60+, 40-59, <40), triglycerides (4 NCEP categories: <150, 150-199, 200-499, 500+), cholesterol medication, current drinking status, education (3 categories: less than high school, high school or some college, bachelor's degree or more), and total intentional exercise (4 quartiles).

†BMI ranges for Normal, Overweight, Class 1 Obese 1, and Class 2/3 Obese categories are, in kg/m^2, respectively: 18.5 – 24.9, 25-29.9, 30-34.9, and ≥35 in Caucasians, African Americans, and Hispanics, and are: 18.5-22.9, 23-27.4, 27.5-29.9, and ≥30 in Chinese.

‡Optimal waist is: <102cm in men and < 88cm in women for Caucasian, African American, and Hispanic, and <90cm in men and <80cm in women for Chinese

§BP ≥ 140/90 or taking antihypertension medication.