NIH Public Access
Author Manuscript
Asia Pac J Clin Nutr. Author manuscript; available in PMC 2014 June 11.

Published in final edited form as:
Asia Pac J Clin Nutr. 2013 ; 22(4): 626–634.

Associations of body mass index with incident hypertension in American white, American black and Chinese Asian adults in early and middle adulthood: the Coronary Artery Risk Development in Young Adults (CARDIA) study, the Atherosclerosis Risk in Communities (ARIC) study and the People's Republic of China (PRC) study

Eva G Katz, PhD, MPH, RD[1], **June Stevens, PhD**[1,2], **Kimberly P Truesdale, PhD**[1], **Jianwen Cai, PhD**[3], **Kari E North, PhD**[2], and **Lyn M Steffen, PhD**[4]

[1]Department of Nutrition, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

[2]Department of Epidemiology, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

[3]Department of Biostatistics, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

[4]Division of Epidemiology and Community Health, University of Minnesota, Minneapolis, MN, USA

Abstract

The association of body mass index (BMI) with blood pressure may be stronger in Asian than non-Asian populations, however, longitudinal studies with direct comparisons between ethnicities are lacking. We compared the relationship of BMI with incident hypertension over approximately 9.5 years of follow-up in young (24-39 years) and middle-aged (45-64 years) Chinese Asians (n=5354), American Blacks (n=6076) and American Whites (n=13451). We estimated risk differences using logistic regression models and calculated adjusted incidences and incidence differences. To facilitate comparisons across ethnicities, standardized estimates were calculated using mean covariate values for age, sex, smoking, education and field center, and included the quadratic terms for BMI and age. Weighted least-squares regression models with were constructed to summarize ethnic-specific incidence differences across BMI. Wald statistics and *p*-values were calculated based on chi-square distributions. The association of BMI with the incidence difference for hypertension was steeper in Chinese ($p<0.05$) than in American populations during young and middle-adulthood. For example, at a BMI of 25 vs 21 kg/m^2 the adjusted incidence differences per 1000 persons (95% CI) in young adults with a BMI of 25 vs those with a BMI of 21 was 83 (36-130) for Chinese, 50 (26-74) for Blacks and 30 (12-48) for Whites; among middle-aged adults it was 137 (77-198) for Chinese, 49 (9-88) for Blacks and 54 (38-69) for Whites. Whether

Corresponding Author: Dr Eva G Katz, 135 Dauer Drive, Campus Box 7461, Chapel Hill 27599, U.S.A. Tel: (908) 210-0904; Fax: (919) 966-7215, evakatz@gmail.com.

AUTHOR DISCLOSURES
The author has no conflict of interest to declare.

hypertension carries the same level of risk of stroke or cardiovascular disease across national or ethnic groups remains uncertain.

Keywords

blood pressure; multi-ethnic; obesity; African American; cardiovascular disease

INTRODUCTION

Studies in China have shown that the risk of hypertension and other cardiovascular risk factors increase with increasing BMI (in kg/m^2) within the range considered normal,[1-10] according to WHO standards (<25). These studies,[1-10] have concluded that a BMI of 23-24 may be a better cut-off point to define overweight in Chinese populations. The China Department of Disease Control, Ministry of Health responded to the body of literature by adopting country-specific BMI cutoff points which define overweight and obesity at BMI values of >24 and >28, respectively, lower thresholds than those established by the WHO of >25 and >30.[2,11]

Most of the studies examining the association of BMI and hypertension in Chinese do not include a Caucasian comparison group. Our research group published the only study,[12] directly comparing the incidence of hypertension by BMI among Chinese Asians, American Blacks and American Whites. Our results supported a stronger influence of BMI on incident hypertension among Chinese Asians, aged 45-64 years at baseline, over approximately 8 years of follow up. Although the BMI associated incidence rate was higher in Chinese Asians, the BMI-adjusted prevalence of hypertension was 29.6% in Chinese Asians, 22.5% in American Whites, and substantially higher in American Blacks (44.2%). As prevalent cases of hypertension are excluded from an incidence analysis, we proposed it would be important to explore ethnic differences in the BMI associated incidence of hypertension during young adulthood, before many of the hypertension cases developed. We hypothesized that susceptibility to the effects of BMI might differ by age and by ethnicity which led us to examine these associations in a younger cohort of Chinese Asians, American Blacks and American Whites, and compare results to a middle-aged population.

MATERIALS AND METHODS

Overview

Data for this analysis were from Chinese Asian, American Black and American White men and women from three prospective, observational studies of the natural history and risk factors for cardiovascular disease. In an effort to be concise, we will refer to the three ethnic groups as Chinese, Blacks and Whites throughout the remainder of the paper. Chinese (young and middle-aged adults) were from the People's Republic of China (PRC) study, Black and White adults were from the Coronary Artery Risk Development in Young Adults (CARDIA) study (young) and the Atherosclerosis Risk in Communities (ARIC) study (middle-aged). We limited the use of data from each cohort to three examinations to result in similar lengths of follow up for Chinese, Blacks and Whites, respectively, in young (10.0, 10.0, 10.1 years) and middle (9.9, 8.5, 8.8 years) adulthood (Table 1). We also matched the ages of participants in these different cohorts by including only participants between 24-39 or 45-64 years of age at baseline.

Cohorts

The PRC Study data—The PRC Study included adult working men and women from urban and rural regions of Guangzhou (Southern China) and Beijing (northern China), with a "chunk" sample of at least 2000 adults (1000 men and 1000 women) from each population. Analyses were limited to subjects from Guangzhou as data from Beijing were very limited for the young adult group. Requests to participate were made to age-eligible males and females. The Guangzhou urban sample included largely employed manual workers, plus some engineers, technicians, physicians, and retired workers from eight of the 25 workshops for the Guangzhou Shipyard Company. The Guangzhou rural sample included men and women working in 14 of 21 agricultural villages near Guangzhou in the Dashi township of Panyu County at the time of the 1981 census.[13] Baseline data were collected in 1983–1984 and follow-up examinations in 1987-88 and 1993-94.

The CARDIA study data—The CARDIA Study is an on-going, multi-site investigation examining young adult Black and White men and women.[14,15] In 1985-86, study baseline data were collected from 5,115 participants recruited from four U.S. sites (Birmingham, AL; Chicago, IL; Minneapolis, MN; and Oakland, CA) with the goal to provide approximately equal numbers within subgroups of race, gender and education. To match follow-up period and age ranges of subjects in PRC, we used data from 1990-1991 (CARDIA study Year 5) as baseline for this analysis and data from 1995-1996 (Year 10) and 2000-2001 (Year 15) for follow-up examinations.

The ARIC study data—The ARIC study,[16] is an on-going investigation of participants from four US communities (Forsyth County, NC; Jackson, MS; the northwestern suburbs of Minneapolis, MN; and Washington County, MD). Baseline data were collected in 1987-1989 from 15,792 White and Black men and women, aged 45-64 years. The two follow-up examinations used in this analysis occurred during 1990-92 and 1996-98.

There are many similarities in the design and data collection among the three cohorts. The Collaborative Studies Coordinating Center (CSCC) at the University of North Carolina at Chapel Hill served as the coordinating center for both the PRC and ARIC studies. The coordinating center provided training manuals and protocols for data collection and was responsible for data processing and review for both studies. The Institutional Review Board (IRB) at each field center approved the study and this analysis was approved by the University of North Carolina at Chapel Hill IRB on research involving human subjects.

Data collection

For all three studies, data were collected in examination centers. In each cohort, participants wore light clothing or a scrub suit without shoes during anthropometric measurements. BMI was calculated as weight (kg)/height $(m)^2$. In all models, BMI was included as a continuous variable.

Trained certified technicians measured and recorded blood pressure at each visit using a random zero mercury sphygmomanometer on the right arm with the participant seated. For all analyses, the average of the last two blood pressure measurements was used.

Information on antihypertensive medication use was collected by self-reported questionnaires and followed by interviewer assisted follow-up as needed. Blood pressure thresholds were based on the National High Blood Pressure Education Program Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure.[17] Participants were classified as hypertensive if 1) systolic blood pressure (SBP) >140 mmHg, 2) diastolic blood pressure (DBP) >90 mmHg; or 3) self-report of current antihypertensive medication use. Hypertension incidence was defined as subjects who were free of hypertension at baseline but hypertensive at a follow-up visit.

Participants self-reported several demographic and lifestyle information including age, sex, race, current smoking status and highest education obtained. Diet was not assessed for PRC and measures of physical activity were not comparable across studies. Therefore, diet and physical activity were not included.

In young adults, participants were excluded if pregnant at baseline (n=23 Black and n=33 White) or missing BMI 11 Chinese, 13 Blacks and 8 Whites), blood pressure (n=2 Black and n=1 White) or covariates (n=17 Chinese, n=8 Black and n=9 White). The analysis sample included 2896 Chinese, 1956 Black and 2114 White young adults. For incidence analysis, we also excluded participants with hypertension at baseline (n=81 Chinese, n=128 Black and n=61 White), pregnant during follow-up (n=3 Chinese, n=7 Black and n=30 White) and subjects with incomplete follow-up data (n=426 Chinese, n=428 Black and n=311 White).

In middle-aged adults, we excluded 55 Blacks from Washington County, MD or Minneapolis, Minnesota, and the participants (n=48) who classified their ethnicity as other than White or Black because they were too small in number to allow ethnic and field center specific analyses. Additionally, participants were excluded if missing BMI (n=11 Chinese, n=19 Black and n=20 White), blood pressure (n=2 Black and n=3 White) or covariates (n=16 Chinese, n=15 Black and n=15 White). The analysis sample included 2458 Chinese, 4120 Blacks and 11,337 Whites in the middle-aged adult prevalence sample. For the incidence analysis, we also excluded participants with hypertension at baseline (n=355 Chinese, n=2400 Black and n=3721 White) and incomplete follow up data (n=508 Chinese, n=470 Black and n=1268 White).

Statistical analyses

Interactions between gender and BMI were not significant and therefore data from men and women were combined and analyses were stratified by ethnic-specific age group and gender was included as a covariate in all models. Logistic regression models also included field center, age (years), current smoking status (smoker/non-smoker), and education level (less than high school, high school, more than high school in American populations and the best equivalent of less than secondary, secondary and greater than secondary in the Chinese population). As a large proportion of Chinese were missing education status, we created a category for unknown education for PRC participants. For all outcomes, alcohol consumption was included as a covariate in preliminary models but was not included in the final models because associations of alcohol with outcomes were not statistically significant (p>0.05) and inclusion of alcohol in the models did not influence the coefficients associated with the variables of interest.

We estimated risk differences using logistic regression models and calculated the adjusted prevalence and incidence and the incidence difference using the "pr value" command,[18,19] in Stata (Version 10.0). To facilitate comparisons across ethnicities, standardized estimates were calculated using the mean age (32 years for young adults and 52 years for middle-aged adults), the overall distribution of gender (44% men), for a non-smoker with a high-school or secondary education and the study specific distribution of participants within field centers. Quadratic terms for BMI and age were tested and included as they were statistically significant (p<0.05). The delta method was used to calculate the standard errors and 95% confidence intervals for the prevalence, incidence and incidence difference. To summarize the ethnic-specific incidence difference results across BMI, we constructed weighted least-squares regression models with the adjusted incidence differences as the dependent variables and BMI as the independent variables. The adjusted incidence differences were calculated for BMI range of 18-35 kg/m^2. The weight was the inverse of the estimated variance of the adjusted incidence difference. Wald statistics and p values were calculated based on chi-square distribution with 1 degree of freedom (df) to compare ethnic group pairs when the relationships were linear. When the relationships were quadratic, principal component analysis was used to orthogonally transform the linear and quadratic terms for BMI. Joint tests of the linear and quadratic terms to compare ethnic pairs were calculated using the Wald statistic and the p values were calculated based on chi-square distribution with 2 df

RESULTS

Baseline characteristics are presented in Table 2. Mean BMI in kg/m^2 was lowest among Chinese (20) and over 90% of the Chinese were underweight (<18.5) or normal weight (18.5- <25). The ethnic differences in BMI distribution limited the regression analyses, whereby, results were presented within a lower and narrower BMI range for Chinese compared to Blacks and Whites, who have a higher mean BMI (Figures 1 and 2). Antihypertensive medication use was negligible among young adult Chinese (0.1%) and Whites (0.7%) and slightly more common among Blacks (2.6%). Use of antihypertensive medication was low among middle-aged Chinese (1.5%), and higher among the American populations (43.7% in Blacks and 25.9% in Whites). We also examined the mean values of SBP and DBP among individuals who were not using antihypertensive medications. Mean SBP and DBP were lower in the non-medicated sample by 0.5-2.7 mmHg and 0.3-1.3 mmHg, respectively, compared to the overall population (not shown).

The crude and adjusted, predicted prevalence and incidence of hypertension are presented in Table 3. Among young adults, the adjusted prevalence (95% CI) of hypertension was significantly higher in Blacks (4.4 (2.4, 6.4)) compared to Whites (1.1 (0.3, 2.0)) and the adjusted incidence of hypertension was significantly higher in Blacks (18.5 (13.9, 23.1)) compared to Chinese (5.3 (2.9, 7.6)) and Whites (6.1 (3.5, 8.6)). Among middle-aged adults,

NIH-PA Author Manuscript

NIH-PA Author Manuscript

the adjusted prevalence of hypertension was significantly higher in Blacks (40.0 (35.1, 45.0)) compared to Chinese (17.2 (9.2, 25.3)) and Whites (17.5 (15.9, 19.2)) (Table 3) and the adjusted incidence of hypertension was signifcantly higher in Blacks (35.4 (27.2, 43.7) than Whites (20.8 (18.5, 23.2).

Despite ethnic differences in the adjusted prevalence and incidence of hypertension, a higher BMI was associated with a greater incidence of hypertension among each ethnic group in both young (Figure 1) and middle-aged adults (Figure 2). In young adults, (Table 3), the slope of the incidence difference for hypertension associated with BMI was similar for Blacks and Whites. However, the slope of the incidence difference for hypertension was significantly greater in Chinese compared to the American populations (p<0.05) (Figure 1). For example, at a BMI of 25 kg/m^2 the incidence difference per 1000 persons (95% CI) for Chinese, Black and White young adults was 83 (36, 130), 50 (26, 74) and 30 (12, 48), respectively. In middle-aged adults, the association of BMI with the incidence difference for hypertension was also greater among Chinese compared to Blacks and Whites (p<0.01) (Figure 2). At a BMI of 25 kg/m^2 the incidence difference per 1000 persons (95% CI) for Chinese, Black and White middle-aged adults was 137 (77, 198), 49 (9, 88) and 54 (38, 69), respectively. This suggests that BMI has a stronger effect on incident hypertension within the BMI range of 18-27 kg/m^2 in Chinese compared with blacks or whites.

DISCUSSION

We found that ethnicity modifies the effect of BMI on incident hypertension. Specifically, the Chinese had a steeper association of BMI with the incidence of hypertension compared to Blacks and to Whites in both young and middle adulthood as evidenced by the steeper slope of the incidence difference. While both young and middle-aged Blacks have a high prevalence and incidence of hypertension across all BMI values, the association of BMI with the incidence difference for hypertension was not as strong as that observed for Chinese. This combination of results suggests that hypertension incidence is more strongly related to BMI in Chinese than Blacks or Whites and the higher prevalence and incidence of hypertension in Blacks compared to Chinese could be due to factors other than BMI. Blacks may experience hypertension due to additional risk factors beyond obesity, which were unmeasured in our study, such as dietary factors, physical activity, environmental stressors or potentially genetic differences.[20-22]

Other studies in China and the United States have shown increasing prevalence and incidence of hypertension associated with an increase in BMI. However, few studies have compared the association in both Chinese and Caucasian populations,[12,23-28] and even fewer have studied the relationship in Chinese, Caucasian and African American populations.[12,24,26] In addition, comparisons of the effect of obesity on hypertension between ethnic populations typically employ ratio measures which must be interpreted carefully. As demonstrated by Stevens *et al*,[29] conclusions regarding the relative effect of obesity in Black versus White adults were contradictory when calculated as risk ratio versus risk difference measures. This was driven by differences in the rate at the reference level of adiposity between ethnic groups and the impact of using a multiplicative as opposed to an additive risk assessment.[30,31] Therefore, we calculated difference measures to compare estimates among ethnic groups.

In addition to the use of ratio measures, the majority of analyses which assess ethnic differences in the BMI-hypertension relationship were cross-sectional in design. This limited the ability to understand temporal sequences of associations. However, these studies also support a greater association of BMI with hypertension in Asian compared to non-Asian populations. Bell *et al*[32] used cross-sectional data to compare the adjusted prevalence and odds of hypertension in 30-65 year old Chinese Asian adults from the China Health and Nutrition Survey with American Black and White adults from the Third National Health and Nutrition Examination Survey (NHANES III). The authors found that the age-adjusted odds ratio for hypertension was significantly greater in Chinese Asian men, at BMI values in the upper normal, overweight and obese categories, when compared to American White men from NHANES III. Similarly, Chinese Asian Women had a significantly higher odds ratio for hypertension when compared to American White women within the BMI range of 27-28.9 kg/m^2. Pan *et al*,[26] compared American Whites and Blacks from NHANES III to a Taiwanese Asian population from the Nutrition and Health Survey in Taiwan. BMI cut-offs that maximized the sum of the sensitivity and specificity in predicting prevalent hypertension were between 23.3 and 23.7 kg/m^2 for Taiwanese males and females, respectively, and higher, between 25.6-28.2 kg/m^2 for American White and Black males and females. The Obesity in Asia collaborative (OAC) addressed the relationship of anthropometric measures with cardiovascular risk factors in Asian compared to Caucasian populations by combining existing data sources.[23] Asians within China, Hong Kong, India, Korea, Japan, Singapore, Thailand, and Taiwan were collectively compared to Caucasians within Australia and Iran. Results from this meta-analysis did support a greater risk of hypertension and other CVD related risk factors in Asians compared to Caucasian populations. Razak *et al*[27,28] analyzed cross-sectional data from Canadian Chinese and Caucasians from the Study of Health Assessment and Risk in Ethnic groups (SHARE) cohort. The 2005 study found an increase in median systolic blood pressure with increasing BMI quintile in both Caucasian and Chinese populations with adjustment for age and sex.[27] The increase was steeper in the Chinese compared to Caucasians.

From this and other studies, the association of obesity with hypertension in Chinese populations appears stronger than that observed in non-Asian populations, even within normal BMI ranges (18.5≤BMI<25 kg/m^2). Although the proportion of adults, who are overweight or obese in China, is less than that of the United States, obesity is rapidly becoming more prevalent in China. In the time since data was collected for this study, the prevalence of obesity has increased dramatically within Mainland China.[33] Our population of Chinese adults was very lean in 1983-84, as less than 6% had a BMI of 25 kg/m^2 or higher. More recent estimates suggest 21%, or more than 1.1 billion of the mainland adult Chinese population are overweight or obese (BMI ≥25 kg/m^2).[34] Despite the leanness of our sample, the association of BMI with blood pressure was significantly greater than that of American populations where the mean BMI is much higher.[33,35-37] A major limitation of this study is that we could not control for differences in diet or physical activity. Data from the CARDIA study have shown blood pressure was inversely associated with physical activity, dietary potassium and protein and these factors accounted for some of the ethnic differences in blood pressure levels.[38] And in China, diet and physical activity have also been linked to regional differences in blood pressure.[39] Without comparable measures of diet and physical activity between populations, we cannot determine whether the stronger association of BMI with hypertension incidence in Chinese compared to US populations was due to differences in diet and physical activity. Additionally, this work is limited in that we did not include other potential confounders such as family history, uric acid and insulin due to lack of data.

This is the first longitudinal study to examine the association of BMI with hypertension and elevated blood pressure in Chinese Asians, American Blacks and American Whites during two different stages of adulthood. Strengths of this work include the use of the CARDIA, ARIC and PRC datasets which provide some of the best data currently available, given our goals. There are many similarities between cohorts, including the study design and data collection, quality control, longitudinal design and use of measured anthropometry. Further strengths of our study include the use of continuous BMI rather than categorical and computing estimates using difference measures rather than ratio measures to compare risks across ethnicities. There are differences in calendar year across samples but because the PRC sample is from China and the CARDIA sample is from the US, we did not expect calendar time to be as relevant a criterion to match samples as duration of follow up and age range since the environment in China and the US are very different for all of the years available.

Based on the results of our study and relevant literature, the association of BMI with blood pressure appears to be stronger in Chinese Asians compared to American White and American Black populations. However, it cannot be ignored that American Blacks have a disproportionately high burden of hypertension across all BMI levels. Further, it is not known whether hypertension carries the same level of risk of stroke or cardiovascular disease across different national and ethnic groups. This supports the need for tailored public health strategies to promote healthy blood pressure levels and encourage a healthy BMI among populations.

Acknowledgments

This work was supported by the National Heart, Lung, and Blood Institute under contracts N01-HV-12243, N01-HV-08112, and N01-HV-59224 with the University of North Carolina, Chapel Hill, NC and the People's Republic of China Ministry of Public Health, the Cardiovascular Institute and Fu Wai Hospital, Chinese Academy of Medical Sciences, Beijing, and the Guangdong Provincial Cardiovascular Institute, Guangzhou. The authors thank the staff and participants of the PRC study for their important contributions. The Atherosclerosis Risk in Communities Study is supported by National Heart, Lung, and Blood Institute contracts (HHSN268201100005C, HHSN268201100006C, HHSN268201100007C, HHSN268201100008C, HHSN268201100009C, HHSN268201100010C, HHSN268201100011C, and HHSN268201100012C). The authors thank the staff and participants of the ARIC study for their important contributions. Supported by the Carolina Program for Health and Aging Research (CPHAR) of the University of North Carolina Institute on Aging: 2T32AG000272-06A2 and by a grant (RR00046) from the General Clinical Research Centers program of the Division of Research Resources, National Institutes of Health and by a grant (R01 DK069678) from the National Institute of Diabetes and Digestive and Kidney Diseases: P30DK056350-05S2.

REFERENCES

1. Bei-Fan Z. Predictive values of body mass index and waist circumference for risk factors of certain related diseases in Chinese adults: study on optimal cut-off points of body mass index and waist circumference in Chinese adults. Asia Pac J Clin Nutr. 2002:S685–93. doi: 10.1046/j.1440-6047.11.s8.9.x. [PubMed: 12534691]
2. Hu FB, Wang B, Chen C, Jin Y, Yang J, Stampfer MJ, et al. Body mass index and cardiovascular risk factors in a rural Chinese population. Am J Epidemiol. 2000; 1:88–97. doi: 10.1093/oxfordjournals.aje.a010127. [PubMed: 10625178]
3. Weng X, Liu Y, Ma J, Wang W, Yang G, Caballero B. Use of body mass index to identify obesity-related metabolic disorders in the Chinese population. Eur J Clin Nutr. 2006; 8:931–7. doi: 10.1038/sj.ejcn.1602396c. [PubMed: 16465198]
4. Zhou BF. Effect of body mass index on all-cause mortality and incidence of cardiovascular diseases--report for meta-analysis of prospective studies open optimal cut-off points of body mass index in Chinese adults. Biomed Environ Sci. 2002; 3:245–52. [PubMed: 12500665]
5. Tuan NT, Adair LS, Stevens J, Popkin BM. Prediction of hypertension by different anthropometric indices in adults: the change in estimate approach. Public Health Nutr. 2010; 5:639–46. doi: 10.1017/S1368980009991479. [PubMed: 19758482]
6. World Health Organization. The Asia-Pacific perspective: Redefining obesity and its treatment. 2000. Report No
7. WHO Expert Consulation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet. 2004; 9403:157–63. doi: 10.1016/S0140-6736(03)15268-3.
8. Nguyen TT, Adair LS, He K, Popkin BM. Optimal cutoff values for overweight: using body mass index to predict incidence of hypertension in 18- to 65-year-old Chinese adults. J Nutr. 2008; 7:1377–82. [PubMed: 18567764]
9. Nguyen TT, Adair LS, Suchindran CM, He K, Popkin BM. The association between body mass index and hypertension is different between East and Southeast Asians. Am J Clin Nutr. 2009; 6:1905–12. doi: 10.3945/ajcn.2008.26809. [PubMed: 19369374]
10. Wang TD, Goto S, Bhatt DL, Steg PG, Chan JC, Richard AJ, et al. Ethnic differences in the relationships of anthropometric measures to metabolic risk factors in Asian patients at risk of atherothrombosis: results from the Reduction of Atherothrombosis for Continued Health (REACH) Registry. Metabolism. 2010; 3:400–8. doi: 10.1016/j.metabol.2009.08.009. [PubMed: 19800641]
11. Chen C, Lu FC. The guidelines for prevention and control of overweight and obesity in Chinese adults. Biomed Environ Sci. 2004; 17(Suppl):1–36. [PubMed: 15807475]
12. Stevens J, Truesdale KP, Katz EG, Cai J. Impact of body mass index on incident hypertension and diabetes in Chinese Asians, American Whites, and American Blacks: the People's Republic of China Study and the Atherosclerosis Risk in Communities Study. Am J Epidemiol. 2008; 11:1365–74. doi: 10.1093/aje/kwn060. [PubMed: 18375949]
13. People's Republic of China-United States Cardiovascular and Cardiopulmonary Epidemiology Research Group; People's Republic of China--United States Cardiovascular and Cardiopulmonary Epidemiology Research Group. An epidemiological study of cardiovascular and cardiopulmonary disease risk factors in four populations in the People's Republic of China. Baseline report from the P.R.C.-U.S.A. Collaborative Study. Circulation. 1992; 3:1083–96. doi: 10.1161/01.CIR.85.3.1083.
14. Friedman GD, Cutter GR, Donahue RP, Hughes GH, Hulley SB, Jacobs DR Jr. et al. CARDIA: study design, recruitment, and some characteristics of the examined subjects. J Clin Epidemiol. 1988; 11:1105–16. doi: 10.1016/0895-4356(88)90080-7. [PubMed: 3204420]
15. Tallmer J, Scherwitz L, Chesney M, Hecker M, Hunkeler E, Serwitz J, et al. Selection, training, and quality control of Type A interviewers in a prospective study of young adults. J Behav Med. 1990; 5:449–66. doi: 10.1007/BF00844831. [PubMed: 2273523]
16. The ARIC investigators; The ARIC investigators. The Atherosclerosis Risk in Communities (ARIC) Study: design and objectives. Am J Epidemiol. 1989; 4:687–702.

17. Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL Jr, et al. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 report. JAMA. 2003; 19:2560–72. doi: 10.1001/jama.289.19.2560. [PubMed: 12748199]
18. Xu, J.; Long, JS. Confidence intervals for predicted outcomes in regression models for categorical outcomes 2005. [cited 2013/10/29]; Available from: http://www.indiana.edu/~jslsoc/stata/ci_computations/xulong-prvalue-23aug2005.pdf
19. Xu, J.; Long, JS. Using the Delta Method to Construct Confidence Intervals for Predicted Probabilities, Rates, and Discrete Changes 2005. [cited 2013/10/29]; Available from: http://www.indiana.edu/~jslsoc/stata/ci_computations/spost_deltaci.pdf
20. Kuzawa CW, Sweet E. Epigenetics and the embodiment of race: developmental origins of US racial disparities in cardiovascular health. Am J Hum Biol. 2009; 1:2–15. doi: 10.1002/ajhb.20822. [PubMed: 18925573]
21. Dries DL, Victor RG, Rame JE, Cooper RS, Wu X, Zhu X, et al. Corin gene minor allele defined by 2 missense mutations is common in blacks and associated with high blood pressure and hypertension. Circulation. 2005; 16:2403–10. doi: 10.1161/CIRCULATIONAHA.105.568881. [PubMed: 16216958]
22. Katzmarzyk PT, Bray GA, Greenway FL, Johnson WD, Newton RL Jr, Ravussin E, et al. Racial differences in abdominal depot-specific adiposity in white and African American adults. Am J Clin Nutr. 2010; 1:7–15. doi: 10.3945/ajcn.2009.28136. [PubMed: 19828714]
23. Obesity in Asia Collaboration. Is central obesity a better discriminator of the risk of hypertension than body mass index in ethnically diverse populations? J Hypertens. 2008; 2:169–77. doi: 10.1097/HJH.0b013e3282f16ad3.
24. Colin Bell A, Adair LS, Popkin BM. Ethnic differences in the association between body mass index and hypertension. Am J Epidemiol. 2002; 4:346–53. doi: 10.1093/aje/155.4.346. [PubMed: 11836199]
25. Huxley R, James WP, Barzi F, Patel JV, Lear SA, Suriyawongpaisal P, et al. Ethnic comparisons of the cross-sectional relationships between measures of body size with diabetes and hypertension. Obes Rev. 2008:53–61. doi: 10.1111/j.1467-789X.2007.00439.x. [PubMed: 18307700]
26. Pan WH, Flegal KM, Chang HY, Yeh WT, Yeh CJ, Lee WC. Body mass index and obesity-related metabolic disorders in Taiwanese and US whites and blacks: implications for definitions of overweight and obesity for Asians. Am J Clin Nutr. 2004; 1:31–9. [PubMed: 14684394]
27. Razak F, Anand S, Vuksan V, Davis B, Jacobs R, Teo KK, et al. Ethnic differences in the relationships between obesity and glucose-metabolic abnormalities: a cross-sectional population-based study. Int J Obes (Lond). 2005; 6:656–67. doi: 10.1038/sj.ijo.0802937. [PubMed: 15782225]
28. Razak F, Anand SS, Shannon H, Vuksan V, Davis B, Jacobs R, et al. Defining obesity cut points in a multiethnic population. Circulation. 2007; 16:2111–8. doi: 10.1161/CIRCULATIONAHA.106.635011. [PubMed: 17420343]
29. Stevens J. Ethnic-specific revisions of body mass index cutoffs to define overweight and obesity in Asians are not warranted. Int J Obes Relat Metab Disord. 2003; 11:1297–9. doi: 10.1038/sj.ijo.0802417. [PubMed: 14574338]
30. Stevens J. Impact of age on associations between weight and mortality. Nutr Rev. 2000; 5:129–37. doi: 10.1111/j.17 53-4887.2000.tb01847.x. [PubMed: 10860392]
31. Stevens J, Juhaeri, Cai J, Jones DW. The effect of decision rules on the choice of a body mass index cutoff for obesity: examples from African American and white women. Am J Clin Nutr. 2002; 6:986–92. [PubMed: 12036803]
32. Chien KL, Hsu HC, Chen WJ, Chen MF, Su TC, Lee YT. Familial aggregation of metabolic syndrome among the Chinese: report from the Chin-Shan community family study. Diabetes Res Clin Pract. 2007; 3:418–24. doi: 10.1016/j.diabres.2006.09.026. [PubMed: 17097184]
33. Wu Y, Huxley R, Li M, Ma J. The growing burden of overweight and obesity in contemporary China. CVD Prevention and Control. 2009; 1:19–26. doi: 10.1016/j.cvdpc.2008.11.003.
34. Tomlinson B, Deng HB, Thomas GN. Prevalence of obesity amongst Chinese populations revisited. Futrure Lipidology. 2008; 2:139–52.

35. Mittal BV, Singh AK. Hypertension in the developing world: challenges and opportunities. Am J Kidney Dis. 2010; 3:590–8. doi: 10.1053/j.ajkd.2009.06.044. [PubMed: 19962803]

36. Gu D, Reynolds K, Wu X, Chen J, Duan X, Muntner P, et al. Prevalence, awareness, treatment, and control of hypertension in china. Hypertension. 2002; 6:920–7. [PubMed: 12468580]

37. Asia Pacific Cohort Studies Collaboration. The burden of overweight and obesity in the Asia-Pacific region. Obes Rev. 2007; 3:191–6. doi: 10.1111/j.1467-789X.2006.00292.x.

38. Liu K, Ruth KJ, Flack JM, Jones-Webb R, Burke G, Savage PJ, et al. Blood pressure in young blacks and whites: relevance of obesity and lifestyle factors in determining differences. The CARDIA Study. Coronary Artery Risk Development in Young Adults. Circulation. 1996; 1:60–6. doi: 10.1161/01.CIR.93.1.60. [PubMed: 8616942]

39. Zhao L, Stamler J, Yan LL, Zhou B, Wu Y, Liu K, et al. Blood pressure differences between northern and southern Chinese: role of dietary factors: the International Study on Macronutrients and Blood Pressure. Hypertension. 2004; 6:1332–7. doi: 10.1161/01.HYP.0000128243.06502.bc. [PubMed: 15117915]

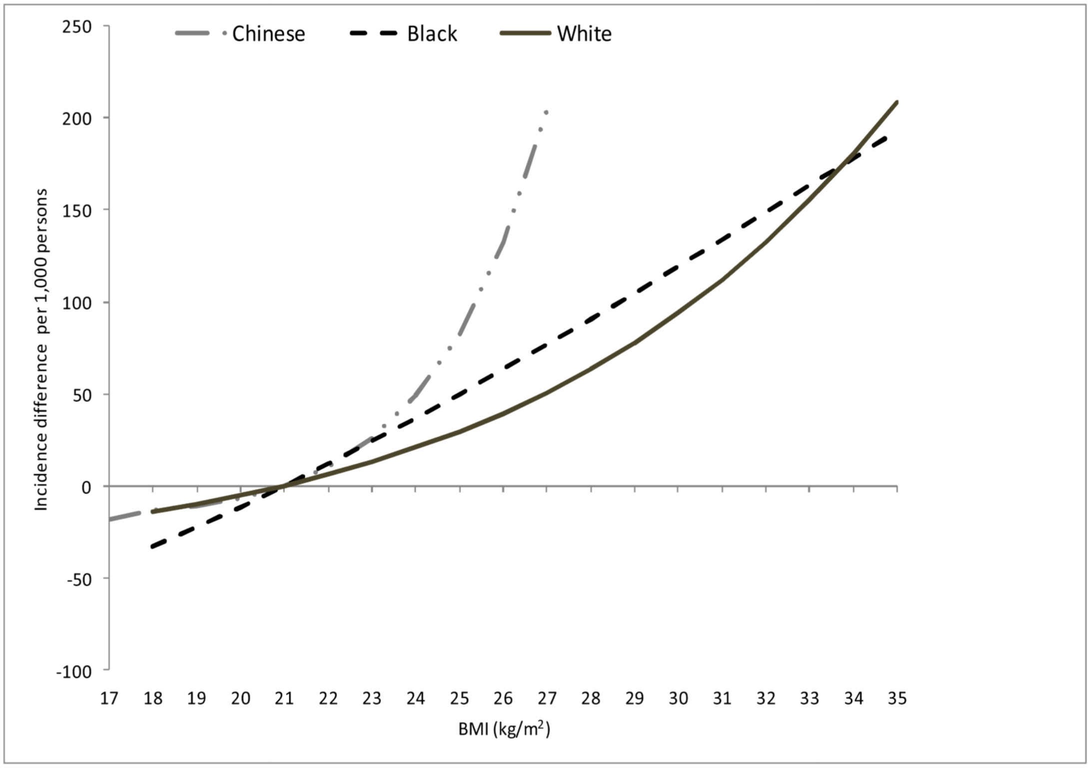

Figure 1.

Adjusted incidence difference per 1,000 persons for hypertension (SBP/DBP ≥140/90 mmHg or blood pressure meds) in young adults (24-39 years), by race. Models were adjusted for age, age^2, sex, smoking, education and field center and included the quadratic term for BMI. Incidence differences were computed using a BMI of 21.0 kg/m^2 as the referent. *Estimates for Chinese were significantly different (p<0.05) from Whites and from Blacks.

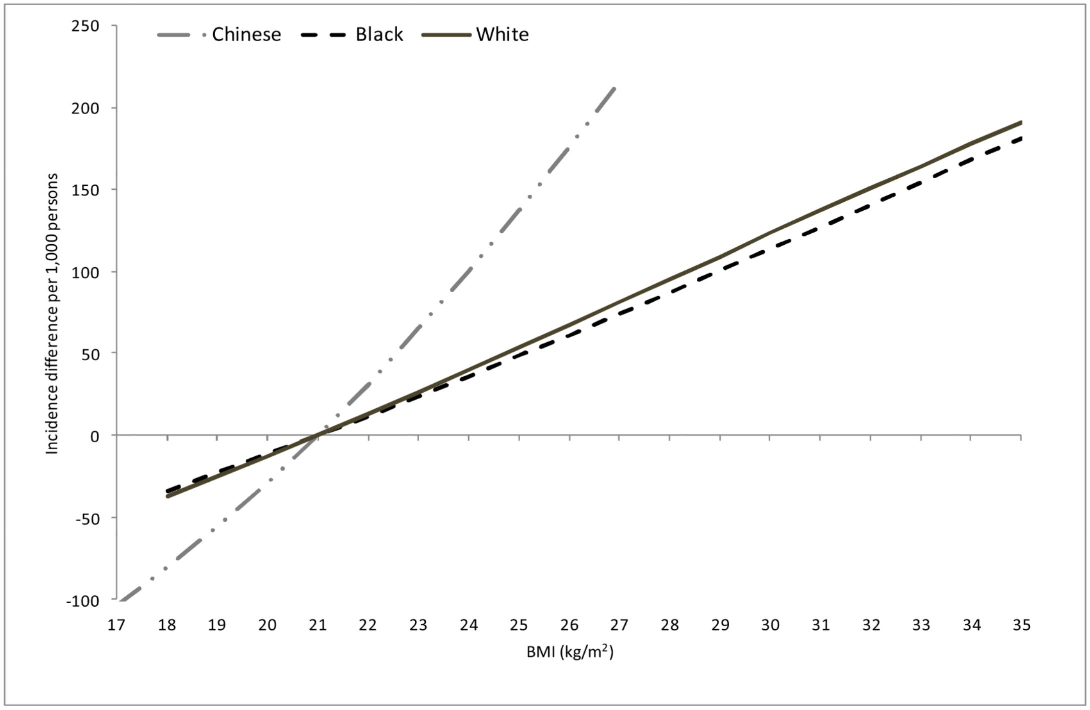

Figure 2.

Incidence difference per 1,000 persons for hypertension (SBP/DBP ≥140/90 mmHg or blood pressure medications) in middle-aged adults (45-64 years), by race. Models were adjusted for age, age^2, sex, smoking, education and field center and included the quadratic term for BMI. Incidence differences were computed using a BMI of 21.0 kg/m^2 as the referent. *Estimates for Chinese were significantly different (p<0.05) from Whites and from Blacks.

Table 1

Overview of study populations

	Young adults (24-39 years)			Middle-aged adults (45-64 years)		
	Chinese	**American Black**	**American White**	**Chinese**	**American Black**	**American White**
Cohort	PRC	CARDIA	CARDIA	PRC	ARIC	ARIC
Country of origin	China	USA	USA	China	USA	USA
Baseline years	1983-84	1990-91	1990-91	1983-84	1987-89	1987-89
Follow-up visits (years)	4 and 10	5 and 10	5 and 10	4 and 10	3 and 9	3 and 9
Mean (SD) follow-up	10.0 (0.2)	10.0 (0.8)	10.1 (0.5)	9.9 (0.7)	8.5 (1.5)	8.8 (1.0)

Study populations include the People’s Republic of China (PRC) study, the Coronary Artery Risk Development in Young Adults (CARDIA) study and the Atherosclerosis Risk in Communities (ARIC) study.

Table 2

Baseline characteristics of young and middle-aged Chinese Asians, American Blacks and American Whites

	Young adults (24-39 years)			Middle-aged adults (45-64 years)		
	Chinese Asian (n=2,896)	**American Black (n=1,956)**	**American White (n=2,114)**	**Chinese Asian (n=2,458)**	**American Black (n=4,120)**	**American White (n=11,337)**
BMI, kg/m^2, mean (SD)	20.2 (2.1)	27.5 (6.7)	25.0 (4.8)	20.3 (2.8)	29.6 (6.2)	27.0 (4.9)
BMI categories, %						
<18.5 kg/m^2	20.1	2.0	2.7	27.1	1.1	0.9
≥18.5-<25 kg/m^2	77.1	39.7	57.2	66.8	20.8	36.2
≥25-<30 kg/m^2	2.6	31.0	27.8	5.7	37.3	40.1
≥30-<35 kg/m^2	0.1	15.0	8.0	0.2	24.5	16.2
≥35-<40 kg/m^2	0.1	6.8	2.6	0.1	10.3	4.7
≥40 kg/m^2	0.0	5.6	1.7	0.0	6.0	1.8
Age, years, mean (SD)	33.1 (4.2)	29.8 (3.5)	30.7 (3.2)	51.2 (4.7)	53.5 (5.7)	54.3 (5.7)
Gender, % male	43.5	43.1	48.0	42.8	37.8	47.3
Education, %						
< high school	75.1	6.7	2.5	87.1	41.8	17.2
high school	15.5	62.2	37.2	4.0	28.3	45.4
>high school	2.4	31.2	60.3	1.8	30.0	37.4
Smoke, % current	33.4	34.8	23.2	38.7	29.8	24.8
Blood pressure, mmHg, mean (SD)						
Systolic	111 (11.4)	110 (11.9)	106 (11.0)	117 (18.7)	129 (21.5)	119 (17.0)
Diastolic	69.5 (8.9)	71.1 (10.5)	68.2 (9.5)	74.5 (10.8)	79.8 (12.1)	71.6 (10.1)
Antihypertensive medication use, %	0.1	2.6	0.7	1.5	43.7	25.9

Table 3

Crude and adjusted* baseline prevalence and incidence for hypertension among Chinese Asian, American Black and American White young and middle-aged adults

	Young adults (24-39 years)			Middle-aged adults (45-64 years)		
	Cases/sample size (no)	**Adjusted estimate**	**95% confidence interval**	**Cases/sample size (no)**	**Adjusted estimate**	**95% confidence interval**
Hypertension Prevalence						
Chinese Asian	81/2,896	2.3	0.8, 3.9	355/2,458	17.2‡	9.2, 25.3
American Black	128/1,956	4.4†	2.4, 6.4	2,400/4,120	40.0†,§	35.1, 45.0
American White	61/2,114	1.1‡	0.3, 2.0	3,721/11,337	17.5‡	15.9, 19.2
Hypertension Incidence						
Chinese Asian	262/2,386	5.3‡	2.9, 7.6	471/1,595	30.5	18.4, 42.6
American Black	345/1,393	18.5†,§	13.9, 23.1	584/1,250	35.4†	27.2, 43.7
American White	160/1,712	6.1‡	3.5, 8.6	1,955/6,348	20.8‡	18.5, 23.2

Adjusted to represent values for nonsmokers at age 32 for young adults and 52 for middle age adults with a body mass index of 21 kg/m^2, a high school education in Americans and a primary education in Chinese, 44% distribution of males and the distribution of field center.

† = different than White

‡ = different than Black

§ = different than Chinese based on wald test $p<0.05$