Original Article

Asian BMI criteria are better than WHO criteria in predicting Hypertension: A cross-sectional study from rural India

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Abstract

Background: International Obesity Task Force proposed lower body mass index (BMI) cut-off values for defining overweight and obesity in Asian population. However, there is an absence of unanimity regarding the definition of overweight and obesity that is confusing while estimating disease burden, resource allocation, and priority setting. Therefore, the primary aim of the study was to assess the prevalence of overweight and obesity and its predictors as per different criteria (WHO criteria, Modified Asian criteria of BMI classification and BF% estimation by bioelectric impedance analysis technique). The secondary aim was to assess the concordance of overweight and obesity as diagnosed using these three methods. **Methodology:** A community-based cross-sectional study was conducted in a rural area of Rohtak, north India over a period of 1 year with a sample size of 1080. Anthropometric measurements including height, weight, blood pressure, body fat % analysis were recorded using standard protocols. **Results:** The prevalence of overweight and obesity were observed to be 49.62% ($N = 536$) as per the modified criteria for the Asian Indians (BMI $\geq$23 kg/m^2) and 34.62% ($N = 374$) according to WHO criteria (BMI $\geq$25 kg/m^2). A total of 18.3% of the study population were hypertensive. Modified criteria of BMI classification for Asian Indians had high sensitivity (67%) as compared to WHO criteria (55%) in predicting, diagnosing hypertension, and resembled sensitivity estimate obtained through direct body fat percentage estimation (69%). **Conclusion:** Modified criteria of overweight and obesity classification are better in terms of reducing comorbid dysmetabolic conditions, as exemplified by hypertension.

Keywords: Body mass index, body fat percentage, hypertension, obesity, receive operating characteristic

Introduction

The burden of noncommunicable diseases (NCDs) and the associated risk factors is on a rise.[1] In India, cardiovascular diseases (CVDs) such as heart attacks and stroke, diabetes, chronic respiratory diseases (chronic obstructive pulmonary diseases and asthma), and cancer are the four leading cause of death, accounting for over 60% of premature mortality.[2] In terms of attributable deaths globally, leading behavioral and physiological risk factors of NCDs includes being overweight or obese (5%), followed by tobacco use (9%), raised blood glucose (6%), physical inactivity (6%), and raised blood pressure (13%).[3]

The prevalence of obesity in India is on a rise and ranges between 13% and 50% in urban population and 8%–38.2% in rural population.[4] Though dual-energy X-ray absorptiometry has been considered the gold standard for body composition measurements,[5] body mass index (BMI) is still the simplest, yet

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most used anthropometric parameter. However, there is a debate regarding the best BMI classification for the Asian population because of their structural variations compared to the western population. International Obesity Task Force has proposed lower BMI cut-off values for defining overweight and obesity among Asian population.[6] Even then, there is no uniformity among health researchers and primary care/family physicians regarding use of modified criteria, and some researchers still prefer the standard WHO guidelines to define overweight and obesity.[7]

There is scarce literature that depicts advantages of using the modified criteria for Asian population and specifically to Indian community. Use of uniform BMI criteria is needed for screening and management of various vasculo-metabolic dysfunctions. For instance, obesity is one of the known risk factors for developing hypertension[8] but, if we do not have uniform BMI criteria, the purpose of defining guidelines for hypertension prevention cannot be accomplished.

Therefore, the primary aim of the study was to assess the prevalence of overweight and obesity and its predictors as per different criteria (WHO criteria, Modified Asian Indian criteria of BMI classification and BF% estimation by bioelectric impedance analysis technique). The secondary aim was to assess the concordance of overweight and obesity as diagnosed by BMI with direct BF% estimation. The exploratory aim is to assess concordance between overweight and obesity and high blood pressure as per different criteria of fatness estimation.

Materials and Methods

Study design

Community-based cross-sectional study.

Study area

The present study was conducted in Block Beri, District Rohtak (Haryana) which is the rural field practice area of Department of Community Medicine, Post Graduate Institute of Medical Sciences (PGIMS), Rohtak over a period of 1 year (September 2013 to August 2014).

Study population included Ambulatory adults aged ≥20 years residing in the study area for more than 6 months. Bedridden patients, patients with signs and symptoms suggestive of water retention and pregnant females were excluded from the study.

Sample size

Considering the prevalence of overweight and obesity 20%,[9] acceptable margin of error 3%, design effect 1.5, the calculated sample size was 1032 (Stat calc., Version 7.2.0.1).

Sampling technique

Multistage cluster random sampling was used. The detailed sampling technique is described elsewhere.[10]

Data collection

Data were collected using a predesigned, pretested, and semistructured questionnaire through interview after obtaining written and informed consent. Sociodemographic characteristics were recorded and the respondents were privately asked for their anthropometric measurements. Weight of the study participants was measured using digital weighing machine (SECA 874 U digital scale), and height for study participants was measured using stadiometer (SECA 213 Stadiometer).[11] BF% was measured using a commercially available portable device (HBF-306, Omron Health Care Co., Kyoto, Japan) that incorporated a bioelectric impedance analyzer as per the standard protocol. A cut-off score of BF% >25% in males and >30% in females was considered high.[12]

Blood pressure was measured using standard techniques and hypertension was classified using JNC-7 criteria.[13] Hypertensive patients were prescribed basic antihypertensive medicines and counseling services. The needy study participants were referred to a tertiary care center of Haryana for further disease management. To ensure the veracity of the data, coinvestigators randomly cross-checked anthropometric measurements done by the principal investigator for 10% study population.

Data analysis

Collected data were entered in the MS Excel spreadsheet and analysis was carried out using Statistical Package for Social Sciences (SPSS) for Windows version 17.0, (SPSS Inc., Chicago, IL). Adjusted Odds Ratio (aOR) with 95% Confidence interval (CI) were calculated using using binary logistic regression technique.

Results

Prevalence of overweight and obesity

The prevalence of overweight and obesity as per the modified criteria for the Asian Indians (BMI ≥23 kg/m^2) in the study population was observed to be 49.62% (N = 536) and only 34.62% (N = 374) according to WHO criteria (BMI ≥25 kg/m^2). The effects of lowering the cut-off values to define overweight and obesity for Asian Indians is given in Table 1. While there was no change in the percentage of underweight study population, number of people who were in normal category decreased, and the number of overweight and obese study participants increased after using the modified criteria. A little less than half of the participants had high BF% (N = 513; 47.5%).

Predictors of overweight and obesity

The sociodemographic findings of the study participants are depicted in Table 2. On applying logistic regression; female study participants had 4% higher odds to be overweight or obese as compared to the males as per the modified criteria of overweight an obesity for Asian Indians, although it was not statistically significant (aOR: 1.04, CI: 0.781–1.397, P-0.769). Even though age was converted to ordinal scale, linearity of

Table 1: Comparison of prevalence of overweight and obesity in the study population by using two different criteria of BMI classification

	WHO Classification, *n* (%)	Modified Criteria for Asian Indians, *n* (%)	Body fat %
Underweight	138 (12.8)	138 (12.8)	567 (52.5)
Normal	568 (52.6)	406 (37.6)	
Overweight	266 (24.6)	162 (15.0)	513 (47.5)
Obese	108 (10.0)	374 (34.6)	
Combined overweight And obesity	374/1080 (34.6)	536/1080 (49.6)	513/1080 (47.5)

χ^2=199, df=3; *P* value<0.001 (significant)

Table 2: Association of sociodemographic variables with overweight and obesity as per the modified Asian BMI criteria using multivariable logistic regression

Variables	Total study participants	Logistic regression		
		Proportion of total over weight and obese	aOR (C.I.)	*P*
Total	1080 (100)	536 (100)		
Gender				
Male	540 (50)	258 (48.1)	Reference	0.769
Female	540 (50)	278 (51.9)	1.04 (0.781-1.397)	
Age groups (years)				
20-29	216 (20)	86 (16.0)	Reference	
30-39	216 (20)	102 (19.0)	1.226 (0.804-1.870)	0.34
40-49	216 (20)	107 (20.0)	1.306 (0.855-1.994)	0.22
50-59	216 (20)	116 (21.6)	1.633 (1.068-2.495)	0.02
>60	216 (20)	125 (23.3)	2.038 (1.311-3.168)	0.002
Marital status				
Unmarried	105 (9.7)	36 (6.7)	Reference	
Married	959 (88.8)	493 (92.0)	1.512 (0.929-2.462)	0.12
Widowed/separated	16 (1.5)	7 (1.3)	1.185 (0.370-3.789)	0.80
Education status				
Illiterate	372 (34.4)	191 (35.6)	Reference	
Primary	77 (7.1)	29 (5.4)	0.382 (0.223-0.655)	<0.01
Middle school	175 (16.2)	68 (12.7)	0.441 (0.284-0.685)	<0.01
High school	362 (33.5)	191 (35.6)	0.635 (0.427-0.944)	0.03
Graduate and above	94 (8.7)	57 (10.6)	0.795 (0.463-1.365)	0.4
Socioeconomic status				
Lower	153 (14.2)	53 (9.9)	Reference	
Lower middle	510 (47.2)	246 (45.9)	2.603 (1.711-3.962)	<0.01
Middle	367 (34.0)	204 (38.1)	3.589 (2.227-5.784)	<0.01
Upper middle	43 (4.0)	28 (5.2)	4.987 (2.254-11.032)	<0.01
Upper	7 (0.6)	5 (0.9)	7.523 (1.299-43.561)	0.02

the *ln (odds)* of obesity with age was not assumed. Therefore, the age was converted to five categories and 20–29 years age group was taken as a reference category. The relative odds to be overweight or obese are 63% higher for age groups 50–59 years and 103% for >60 years age group as compared to the reference category. (aOR: 1.633, CI: 1.068–2.495, *P*-0.023 and aOR: 2.038, CI: 1.311–3.168, *P*-0.002). Upper class in society had nearly seven times (aOR: 7.523, CI: 1.299–43.561, *P*-0.024) the risk and showed positive association with BMI, but this study finding cannot be generalized because of few number of study participants in this category.

Concordance of different criteria of fatness estimation in predicting hypertension

Analysis of mean blood pressure readings of the study participants depicted that 18.3% participants were hypertensive -12.2% and 6.1% in stage I and II (females: 18.5% and males 18.1%, *P* value >0.05) respectively. Table 3 depicts the prevalence of hypertension as per two different criteria for BMI. Subsequently, the study participants were segregated according to their BF% to directly observe association of body fat with the prevalence of hypertension. Majority of the participants who had normal blood pressure (n = 395) were having low BF% (N = 265, 62.0%), whereas the hypertension was more than double in participants with high body fat (N = 93; 70.5% in Stage I and N = 44; 66.7% in Stage II) as compared to low body fat group (N = 39; 29.5% in Stage I and N = 22; 33.3% in Stage II) (*P* value= ≤0.001). The participants who were in prehypertensive stage were nearly equal in both high BF% and low BF% categories (N = 261; 53.6% and N = 226; 46.4%). (data not tabulated).

The sensitivity and specificity of predicting hypertension through different criteria of fatness estimation was calculated and is stated in Table 4. The increase in sensitivity by modified criteria for Asian Indians exposed more overweight and obese study participants, [N = 22 (2.03%)] who were suffering from hypertension as compared to WHO norms. McNemar test was applied and it was found that the diagnostic criteria to identify hypertensive subjects by modified criteria for Asian Indians have significantly (P < 0.001) better sensitivity than WHO criteria.

Further, the close relation between BMI and BF% was demonstrated by estimating the mean differences and limits of agreement between BMI and BF% according to Bland–Altman procedures. Since, the two variables had different units of measurement, both were first converted to obtain z-score before computing their differences and mean values among study participants to get the final plot [Figure 1]. Good agreement was observed between the two obesity estimation methods. Pearson's correlation analysis showed positive correlations between BMI and BF% (r = 0.747, P < 0.000) and they both were positively correlated to the systolic (r = 0.273 and 0.191; P < 0.000) and diastolic blood pressure (r = 0.277 and 0.165; P < 0.001). However, to compare the discriminatory power of BMI and BF%, ROC analysis was also used and both depicted good discriminatory power to diagnose hypertension in the Indian population [Figure 2]. The area under curve (AUC) for both the methods was observed to be similar (0.668 and 0.627, P value < 0.001).

Discussion

This study reinforces the utility of Asian cut-off to define overweight and obesity in Indian adults in primary care. It also

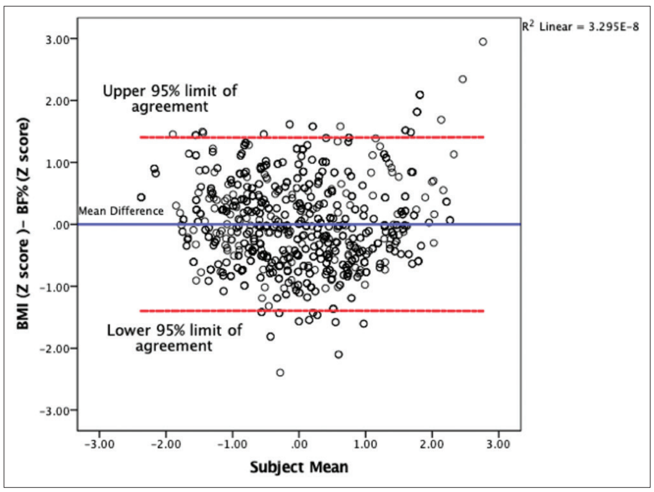

Figure 1: Bland–Altman's plot to assess agreement between overweight/obesity measured by BMI and BF% estimation

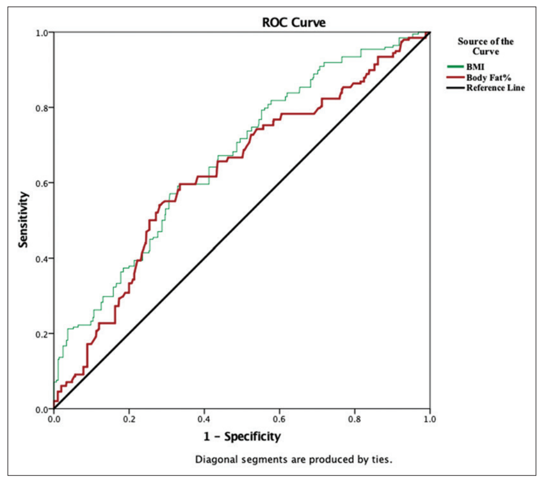

Figure 2: ROC analysis to predict hypertension in the study population by using BMI and BF% estimation methods

Table 3: Prevalence of hypertension in the study population according to two different BMI criteria

	WHO Classification				Modified criteria for Asian Indians				Total n (%)
	Under Weight n (%)	Normal n (%)	Over Weight n (%)	Obese n (%)	Underweight n (%)	Normal n (%)	Over Weight n (%)	Obese n (%)	
Normal	80 (20.3)	223 (56.5)	71 (18.0)	21 (5.3)	80 (20.3)	176 (44.6)	47 (11.9)	92 (23.3)	395 (36.6)
Prehypertension	49 (10.1)	265 (54.4)	130 (26.7)	43 (8.8)	49 (10.1)	174 (35.7)	91 (18.7)	173 (35.5)	487 (45.1)
Stage 1	4 (3.0)	53 (40.2)	47 (35.6)	28 (21.2)	4 (3.0)	33 (25.0)	20 (15.2)	75 (56.8)	132 (12.2)
Stage II	5 (7.6)	27 (40.9)	18 (27.3)	16 (24.2)	5 (7.6)	23 (34.8)	4 (6.1)	34 (51.5)	66 (6.1)
Total	138 (12.8)	568 (52.6)	266 (24.6)	108 (10.0)	138 (12.8)	406 (37.6)	162 (15.0)	374 (34.6)	1080 (100)

Table 4: Validity of two criteria of BMI classification in comparison to body fat percentage estimation for detecting hypertension in the study population

		Hypertension		Validity measures			
		Present	Absent	Sensitivity	Specificity	PPV	NPV
BMI as per WHO criteria	≥25 kg/m²	109	265	55%	69%	29%	87%
	< 25 Kg/m²	89	601				
BMI as per Asian criteria	≥23 Kg/m²	133	401	67%	54%	25%	88%
	<23 Kg/m²	65	465				
Body fat percentage	High	137	376	69%	57%	27%	90%
	Low	61	490				

reinforces the clustering of vasculo-metabolic dysfunctions in overweight and obese individuals and helps to identify such individuals in the nascent stages of disease and prevent complications. Family physicians should make more efforts to screen for hypertension. We can extrapolates this to suggest that screening for other vasculo-metabolic diseases like diabetes and dyslipidemia should be performed more diligently and frequently in person who are overweight and obese as per the new guidelines.

In present study, the overall prevalence of overweight and obesity was found to be unacceptably high among adult rural population which is a cause of serious concern. The observed prevalence is higher than results depicted in different studies that employed the same criteria of classification.[14,15] This increase can be attributed to consumption of high calorie foods along with unhealthy lifestyle in the study area. On applying modified criteria to the same population in our study, the overall prevalence was found to be 49.62%. Similar high prevalence was reported in many other studies done across the country.[16-18] The prevalence of hypertension among study participants was observed as 18.8%. Integrated disease surveillance project in NCDs risk factor survey reported similar high prevalence in rural households, in range of 16%–22% in different states of India.[19] It has been strongly testified that obesity is intimately associated with increased chances for hypertension and other NCDs.[20]

In our study, a difference of about 15% was observed in the prevalence of overweight and obesity by using two different criteria for classification. Therefore, the prevalence of actual fatness was re-estimated with the help of body fat analyzer to get actual estimates. This portable machine has been used in many studies in India and abroad and has been validated.[21,22] The predictive capacity of the BF% analyzed in this study was significant in identifying subjects with hypertension (i.e. AUC > 0.50). BMI and BF% also depicted strong agreement on Bland–Altman's plot and depicted positive correlation with Pearson's correlational analysis. Even on ROC analysis, both BMI and BF% depicted similar discriminatory power to predict hypertension in study population. With this statistical support, it can be concluded that the two methods can be used interchangeably. BMI can be used to depict obesity, as it is not possible to estimate BF% everywhere due to cost and availability of the instrument.

Further, proportion of overweight or obese individuals who were also diagnosed with hypertension increased from 10.2% according to the WHO criteria to 12.5% when classified according to the modified criteria for Asian Indian population. Overall, about 45.1% ($N = 487$) of the study participants were prehypertensive. But, the number of overweight or obese study participants with blood pressure in the prehypertensive range increased from 173 (16.02%) to 264 (24.44%) by the use of modified criteria. Most of these participants with prehypertension will be contributing to the major portion of the hypertension disease burden in future. Just by using modified criteria, it is possible to cover such people through the surveillance radar while their disease is still in initial stages. In developing countries like India where health-seeking behavior is poor, people do not prefer paying visits their with family physicians until their disease has reached advance stages. Benefits of early screening and treatment cannot be ignored. The United States preventive services task force found good-quality evidence that screening for hypertension has few major harms and provides substantial benefits.[23,24]

Conclusion

Modified criteria for the classification of overweight and obesity is better in terms of predicting comorbid dysmetabolic conditions, as exemplified by hypertension. It is therefore recommended to use these criteria uniformly throughout the country in research and primary care without which the control of this modern epidemic is a far-off dream.

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Conflicts of interest

There are no conflicts of interest.

References

1. World Health Organization. Noncommunicable diseases [Internet]. 2018 [cited 2019 Mar 14]. Available from: https://www.who.int/en/news-room/fact-sheets/detail/noncommunicable-diseases.
2. Alwan A, Armstrong T, Bettcher D, Branca F, Chisholm D, Ezzati M, *et al.* Global status report on noncommunicable diseases. Italy; 2011.
3. World Health Organization. NCD mortality and morbidity. Global Health Observatory. Geneva: World Health Organization; 2011. Available from: http://www.who.int/gho/ncd/en/.
4. Misra A, Shrivastava U. Obesity and dyslipidemia in South Asians. Nutrients 2013;5:2708-33.
5. Demmer DL, Beilin LJ, Hands B, Burrows S, Pennell CE, Lye SJ, *et al.* Dual energy X-ray absorptiometry compared with anthropometry in relation to cardio-metabolic risk factors in a young adult population: Is the 'Gold Standard'tarnished?. PloS One 2016;11:e0162164.
6. World Health Organization. The Asia Pacific Perspective- Redefining Obesity and Itstreatment. Geneva: WHO; 2000.
7. Obesity Foundation India [Internet]. [cited 2019 Mar 14]. Available from: http://obesityfoundationindia.com/about.htm.
8. Know Your Risk Factors for High Blood Pressure | American Heart Association [Internet]. [cited 2019 Mar 14]. Available from: https://www.heart.org/en/health-topics/high-blood-pressure/why-high-blood-pressure-is-a-silent-killer/know-your-risk-factors-for-high-blood-pressure#.WlILOVT1XUo.
9. Bhasin, SK, Mehta M, Gupta N, Meena S, Sharma R. A study of hypertension and obesity among the adult population in a rural area near NCT Delhi. Ind Med Gaz 2013;8:296-301.

10. Verma M, Rajput M, Sahoo SS, Kaur N, Rohilla R. Correlation between the percentage of body fat and surrogate indices of obesity among adult population in rural block of Haryana. J Fam Med Primary Care 2016;5:154.
11. World Health Organization. Obesity: Preventing and Managing the Global Epidemic. WHO Technical Report Series, No. 854. Geneva: World Health Organization; 1995. [Last accessed on 2017 Jul 22] Available from: www.who.int/gho/ps/.
12. Dudeja V, Misra A, Pandey RM, Devina G, Kumar G, Vikram NK. BMI does notaccurately predict overweight in Asian Indians in Northern India. Br J Nutr 200;86:105-12.
13. Wilsgaard T, Schirmer H, Arnesen E. Impact of body weight on blood pressure with a focus on sex differences: The Tromso Study, 1986-1995. Arch Intern Med 2000;160:2847-53.
14. Sugathan TN, Soman CR, Sankaranarayanan K. Behavioral risk factors for noncommunicable diseases among adults in Kerala, India. Indian J Med Res 2008;127:555-63.
15. Saxena V, Kandpal SD, Goel D, Bansal S. Prevalence of risk factors on noncommunicable diseases in rural population of block Doiwala, Dehradun. Indian J Community Health 2011;23:65-8.
16. Pradeepa R, Anjana RM, Joshi SR, Bhansali A, Deepa M, Joshi PP, *et al*. Prevalence of generalized & abdominal obesity in urban & rural India-the ICMR-INDIAB Study (Phase-I)[ICMR-INDIAB-3]. The Indian Journal of Medical Research 2015;142:139.
17. Kaur P, Rao SR, Radhakrishnan E, Ramachandran R, Venkatachalam R, Gupte MD. High prevalence of tobacco use, alcohol use and overweight in a rural population in Tamil Nadu, India. J Postgrad Med 2011;57:9-15.
18. Singh RB, Pella D. Prevalence of obesity, physical inactivity and under-nutrition, a triple burden of diseases during transition in a developing economy. The Five City Study Group. Acta Cardiol 2007;62:119-27.
19. Integrated Disease Surveillance Project. Non-communicable disease risk factors survey Phase-1. Ministry of Health & Family Welfare, Government of India 2007-08. New Delhi: MoHFW; 2009. [Last Accessed on 2018 Jul 22]. Available from: http://www.icmr.nic.in/final/IDSP NCD%20Reports/Phase1%20States%20of%20India.pdf.
20. Lu Y, Hajifathalian K, Ezzati M, Woodward M, Rimm EB, Danaei G; Global Burden of Metabolic Risk Factors for Chronic Diseases Collaboration (BMI Mediated Effects). Metabolic mediators of the effects of body-mass index, overweight, and obesity on coronary heart disease and stroke: A pooled analysis of 97 prospective cohorts with 1.8 million participants. Lancet 2014;383:970-83.
21. Mullie P, Vansant G, Hulens M, Clarys P, Degrave E. Evaluation of body fat estimated from body mass index and impedance in Belgian male military candidates: Comparing two methods for estimating body composition. Mil Med 2008;173:266-70.
22. Rutherford WJ, Diemer GA, Scott ED. Comparison of Bioelectrical Impedance and Skinfolds with Hydrodensitometry in the Assessment of Body Composition in Healthy Young Adults. ICHPER-SD Journal of Research 2011;6(2):56-60.
23. Sheridan S, Pignone M, Donahue K. Screening for high blood pressure: A review of the evidence for the U.S. Preventive Services Task Force. Am J Prev Med 2003;25:151-8.
24. Wolff T, Miller T. Evidence for the reaffirmation of the U.S. Preventive Services Task Force recommendation on screening for high blood pressure. Ann Intern Med 2007;147:787-91.